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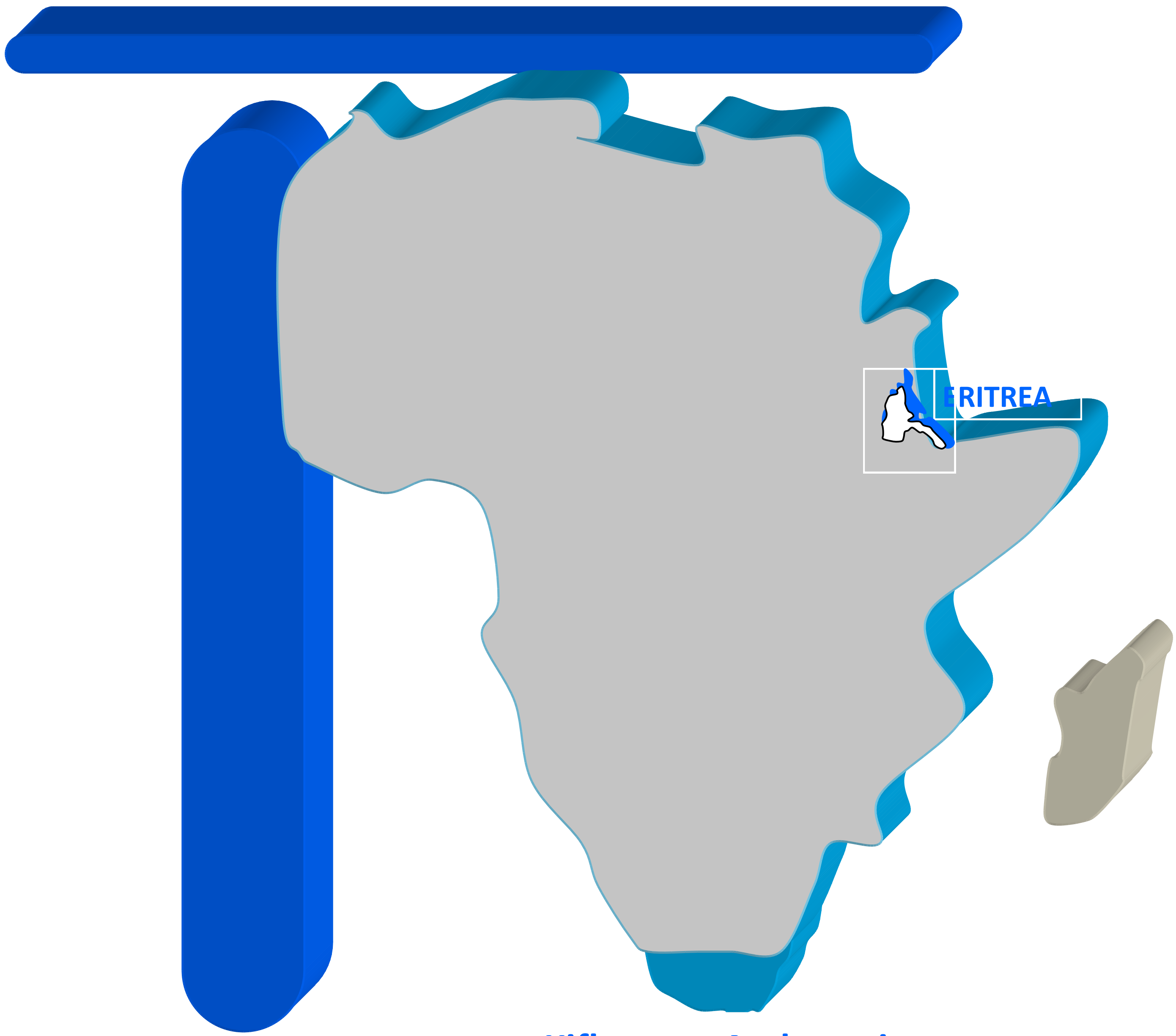
THE CASE OF ERITREA



Kifleyesus Andemariam

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THE CASE OF ERITREA

By
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University of Groningen
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THE CASE OF ERITREA

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Acronyms

AERC	African Economic Research Consortium
AISI	African Information Society Initiative
ANSTI	African Network of Scientific and Technological Institutions
APC	Association for Progressive Communication
AREEDEM	African Regional Centre for Engineering Design and manufacturing
AREN	Agricultural Research Council of Nigeria
ARET	African Regional Centre for Technology
AREC	Agricultural and Resource Economics
AVU	African Virtual University
BE	Bank of Eritrea
BLO	Business Licence Office
BNDE	National Economic Development Bank
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAPRE	Commission for Co-ordination of Electronic Processing Activities
CASE	Computer-Aided Software Engineering
CBE	Commercial Bank of Eritrea
CCS	Centre of Computer Studies
CDI	Industrial Development Council
CDIS	Curriculum Development Institute of Singapore
CEME	State Medicine Centre
CGIAG	Consultative Group for International Agricultural Research
CIDA	Canadian International Development Agency
CIDA	Canadian International Development Agency
CMC	Computer Maintenance corporation
CNC	Committee on National Computerisation
CNPq	National Research Council
CODETEC	Company for Development of Technology
CODESRIA	Development of Economic and Social Research in Africa
COMESA	Common Market of Eastern and Southern Africa
COMESSA	Community of Sahelian-Saharan States
CRAES	African Research for solar Energy
CSCP	Civil Services Computerisation Programme
CSIR	Council for Scientific and Industrial Research
CSIR	Council of Scientific and Industrial Research
DAAD	Deutscher Akademischer Austauschdienst
DANIDA	Danish International Development Agency
DBT	Department of Biotechnology
DFI	Direct Foreign Investment
DISCS	Department of information Systems and Computer Science
DOT	Department of Telecommunications
DSIR	Department of Science and Industrial Research
DST	Department of Science and Technology
ECB	Eritrean Computer Board
EDB	Economic Development Board
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange for administration, Commerce and Transport
EEA	Eritrean Electric Authority

EIM	Eritrean Institute of Management
EISA	Eritrean Information Systems Agency
EPB	Economic and Planning Board
EPLF	Eritrean Popular Liberation Front
ETE	Eritrean Technical Exchange
ETS	Ethiopian Telecommunications Services
FEA	French Equatorial Africa
FINIDA	Finnish international Development Agency
FINTEC	Fondo de Fomento de la Innovacion Tecnologica
FNDCT	Fund for Scientific and Technological Development
GII	Global Information Infrastructure
GIS	Geographic Information system
GSRI	Government Sponsored Research Institutes
GTZ	Gesellschaft fur Technische Zusammenarbeit
HAN	Highly Advanced National Project (Korea)
HSIP	Hsinchu Science-based Industrial Park
IBTDP	Industrial Base technology Development Projects
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ICT	Information and Communication Technologies
ICTP	International Centre for Theoretical Physics
ID	Industrial Department
IDC	International Data Corporation
IDD	International Direct Dial
IDRC	International Development Research Centre
IDRC	International Development Research Institute (Ottawa)
III	Institute for the Information industry
IIP	Intergovernmental Information Programme
IFAD	International Fund for Agricultural Development
IGAD	Intergovernmental Authority on Development
IICD	International Institute for Communication and Development
ILEIA	Information Centre for Low-External-Input and Sustainable Agriculture
IISC	Indian Institute of Science
INDONET	Indian Network
INPI	National Institute of Industrial Property Rights
IPS	Inter Press Service
IRCN	Industrial Research Council of Nigeria
IRI	Industrial Research Institute
ISDN	Integrated Services Digital Network
ISS	Institute of Systems Science
IT	Information Technology
ITPAC	Information Technology Policy Advisory Committee
ITRI	Industrial Technology Research Institute
ITU	International Telecommunication Union
JSIST	Japanese-Singapore Institute of Software Technology
KAIST	Korea advanced Institute of Science and Technology
KARI	Kenya Agricultural Research Institute
KDD	Global Telecommunication Provider of Japan
KEMFRI	Kenya Marine and Fisheries Research Institute
KEMRI	Kenya Medical Research Institute
KETRI	Kenya Trypanosomasis Research Institute

KIRDI	Kenya Industrial Research and Development Institute
KIST	Korea Institute of Science and Technology
KORSTIC	Korea Scientific and Technical Information Centre
LAN	Local Area Network
LCD	Liquid Crystal Display
MCL	Ministry of Commerce and industry
MCST	Ministerial Committee for Science and Technology
MIS	Management Information Systems
MNC	Multi-national Corporation
MOA	Ministry of Agriculture
MOEA	Ministry of Economic Affairs
MOF	Ministry of Finance
MOH	Ministry of Health
MOST	Ministry of Science and Technology
MRCN	Medical Research Council of Nigeria
MSME	Micro, small and medium enterprises
MSTI	Management of Science, Technology and Innovation
MSTP	Market-stimulating Technology Policies
MTI	Ministry of Trade and Industry
NASSCOM	National Association of Software and Service Companies (India)
NCB	National Computer Board
NCSIR	Nigerian Council for Scientific and Industrial Research
NCST	National Council for Science and Technology
NCST	Nigerian Council for Science and Technology
NDC	National Development Council
NBPFP	National Economic Policy Framework and Programme
NFIS	National Food Information System
NICE	National Insurance Corporation of Eritrea
NICNET	National Informatics Centre Network
NIE	Newly industrialised Economies
NII	National Information Infrastructure
NITP	National IT Plan
NORAD	Norwegian Agency for International Development
NPTA	Norwegian Post and Telecommunications Authority
NRC	National Research Council
NRP	National R&D Project
NSRCN	National Sciences Research Council of Nicaea
NSTB	National Science and Technology Board
NSTB	National Science and Technology Board
NSTDA	National Science and Technology Development Agency
NTP	National Technology Plan
NTS	New Technology Systems
NUFFIC	Netherlands Organisation for International Co-operation in Higher Education
OAS	Organisation of American States
ODA	Overseas Development Agency
OECD	Organisation for Economic Co-operation and Development
OSSREA	Organisation for Social Science Research in Eastern (and Southern) Africa
PBDCT	Basic Plans of S&T Development (Brazil)
PFDJ	Popular Front for Democracy and Justice
RCTC	Risk Capital and Technology Finance Corporation
RINAF	Regional Informatics Network for Africa

RSE	Research Scientists and Engineers
S&T	Science and Technology
SAREC	Swedish Agency for Research Co-operation with Developing Countries
SEI	Special Secretariat for informatics
SIDA	Swedish International Development Authority
SME	Small and Medium Enterprises
SNDCT	National System of Scientific and Technological Development
SNS	Singapore Network Services
SSA	Sub-Saharan African
STEPI	Science and Technology Policy Institute
STP	Science and Technology Projects
STP	Software Technology Parks
SUST	Satellite University of Science and Technology
TCS	Tata Consultancy Services
TDC	Trade Development Council
TDICI	Technology Development and Information Company of India
TNC	Trans-national Corporation
TPLF	Tigrean Popular Liberation Front
TSE	Telecommunication Services of Eritrea
UOA	University of Asmara
USAID	United States Agency for International Development
VTC	Vocational Training Council
WAN	Wide Area Network
WTO	World Trade Organisation

Introduction and Theoretical Framework

1. Introduction

1.1 The study background

Most of the people in developing countries live in rural areas and depend on subsistence farming. Otherwise fertile areas are not able to feed the population because of century old farming techniques and technology. The small industry existing is basically on light industries based on simple labour intensive technologies that are unable to compete internationally in terms of quality and price. The productivity of labour is very low because of low level of skills. Illiteracy is a major problem. As a result, many developing countries are in a very poor economic shape. They have tried to follow in the footstep of the industrialised countries to ameliorate their situation without avail. If you see the African continent the view is depressing. The legacy of colonisation, political instability and civil wars, corrupt and inefficient governments as well as the unfavourable trade of primary goods in the international market and the failed industrialisation following their political independence with rising national debts are at the root of their human tragedy, African countries' problems can be seen as the result of manpower training that is not effectively utilised in achieving the expected results in the application of appropriate industrial technology. Research institutions whose result remain at the prototype level; and state and private enterprises that depend more on foreign inputs than indigenous ones. This state of affairs has been partially responsible for Africans economic plight and perpetuates the current dismal state of a large segment of the human race, which has been forced to tolerate poverty, sickness and illiteracy as the normal way of life (ECA, 1991). Eritrea, being the newest nation in Africa and among the least developed countries in the world, is part and parcel of this vicious circle of technological backwardness and underdevelopment. It is trapped between the low level of scientific and technological capability that is not able to meet the growing demand of its people and the lack of purchasing power to buy and absorb science and technology from the advanced countries. It is true that industrialisation can only be based on the development of an adequate technological base through an appropriate application of Science and Technology (S&T) with a view to ensuring an integrated development process with strong inter-sector linkages. And an adequate technological base can only be developed if a country gives due recognition to S&T as an important sector of the national economy (ibid. p.t-3). To get out of the vicious circle, Eritrea should start making a conscious effort to develop appropriate technology policy that clearly shows a nation's leadership desire to enhance the contribution of scientific and technological capabilities for national development. It should increase the diffusion and efficient utilisation of technology, first, and reduce the dependency on foreign technology later. The problem, therefore, is the inability to take advantage of S&T as latecomer advantage and progressively break the vicious circle of absolute dependency.

In Sub-Saharan Africa (SSA), many countries immediately after independence embarked on aggressive industrialisation process by incurring huge development-related debt. They Introduction and Theoretical Framework transplanted modern plants from the West. But later it became evident that technology transfer does not occur only by buying modern machinery. It rather resulted in costly 'white elephants' that drained the meagre resources and produced nothing in return. Hence, the heavy debts on the shoulders of many

African countries that today are almost living on international aid. The obsession of rapid industrialisation is also evident in Eritrea but at the same time the 'fear of debt' to avoid the costly mistakes of other African countries is very much felt. This is a country that from mid 1930s to mid 1960s had experienced a tremendous growth in industrialisation, by developing countries' standard. But at the same time during the 3O-years of war of liberation (1961-1991), it went through the opposite road of underdevelopment.

Now, in the case of Eritrea, the task of 'rapid industrialisation' is daunting given the absence of the large Italian skilled manpower and capital that was at the basis of the rapid industrialisation of the 1930s, 1940s and 1950s. Even the large Eritrean skilled workforce generated at that time was dispersed or sacrificed during the war of liberation, Besides, the world economy has completely changed particularly S&T. IT has become the driving force of progress and development. Now, the world is witnessing a new technological revolution: the information revolution. This revolution is much more than a communication revolution and should not be perceived in a narrow sector sense. It is the merging of two separate fields: computer science and telecommunications (Valaskakis, 1982: 96).

The information revolution is as much a process as a product revolution. Although there are hundreds of new communication products being developed at a very fast rate every year the process of conventional production is also changing as are life styles and values (ibid. p. 97). The most important of the process changes are robotics, office information systems, and ecommerce that is emerging based on the fast expansion of Internet. Factory-automation and office-automation are substantially reducing production costs and reaping comparative advantages for those who adopt them. The micro-electronic revolution is transforming the mode of production in a manner at least as profound as the steam engine two centuries ago. In both cases we have a -industrial process of automation but with a difference. Whereas in earlier phases, energy capital was replacing labour, in the contemporary phase, information capital in the form of computers is replacing human labour.

Any technology has a definite life cycle: discovery, invention, innovation, national dissemination, decline, and obsolescence. A careful study of leading technological countries in the contemporary period does show that their leadership comes from the successful mastery and control of the technology cycle and in particular the use of the "leapfrog" principle. This means either skipping a stage within a technology generation or skipping an entire generation to arrive on the ground floor of the next one before anyone else (ibid.p.98). Therefore, an understanding of the determinants of technical change may therefore have a good deal to gain from a more careful study of organisations and their modes of operation and change (Fransman, 1986: 123).

The potential of information technology (IT) is enormous not just in the communication field but throughout the economy and it is very important that countries adapt their technology strategic orientation accordingly. Ultimately, the leapfrog principle inherent in micro-electric technology presents the single most potent source of hope for the weak of this world because information cannot be hoarded by information-capitalists and used to subjugate others. The leapfrog 'principle' takes care of that (Valaskakii, 1982: 100). But it assumes higher user capacity to select, use and store for future use from the huge information available in our modern world.

The weak in science and technology are the least developed countries like Eritrea. Particularly, the manufacturing industries of these countries are extremely weak. Most of the developing countries have failed in the process of industrialisation. Eritrea, a new nation of Africa born in 1993, must not repeat the mistakes of other African countries. The world is full of success and failure stories. This country must capitalise on such wealth of experiences. Besides, the development information flow is easier than ever before thanks to the revolution in information technology. In this respect and in the process of industrialisation, if there is a possibility of cutting the corners, that can only be achieved by tapping all the potential of information technology. In this endeavour a good technology policy is of great help.

It is time for a conscious effort to establish appropriate technology policy-making bodies within the government structure. These government bodies are missing in most SSA countries. The foundation of S&T has been left to chance factors and is directed indirectly by government macroeconomic and industrial policies as well as the influence of donor countries. Given that the least developed countries have very small markets and industrial base, to expect the private sector to lead in the development of S&T is illogical. The government should play its leading role. But again this can be done if there are only qualified and experienced people to make and implement such policies. Obviously these policies should also be designed to properly co-ordinate activities in education and training to that of industry. Education is supposed to provide all the necessary skilled manpower required to developing and sustaining a competitive industry. Industry, in its turn, should provide goods and services that are internationally competitive to be able to generate enough foreign currency to sustain the development. The development of these institutional infrastructures is going to take a lot of energy, money, and time.

Eritrea, as a new comer, is starting to build its public services structure. It should immediately start to integrate S&T into all of its socio-economic policies. How? This is the study question of this research paper. This research wants to explore the S&T activities in developing countries in order to understand the stumbling blocks that other developing countries have been experiencing in the past and for Eritrea to learn from successes and failures documented in these countries. The main question of this research, therefore, is how Eritrea can transfer S&T, particularly IT, for a successful transformation of its economy and its society and avoid being at the fringe of the new global economy. Obviously the success we have in mind is one possible to measure in terms of the capability to produce internationally competitive goods and services. This, we think, can be achieved by acquiring and assimilating new technologies. And in this policy research, under the title of information technology policy and management in developing countries', we want to contribute on how to best achieve this. The title should not be mistaken for a research on 'management information systems' at firm level. Rather it is S&T study, where II has a prominent place as a pervasive technology, including, of course, computer information systems at micro-level but keeping the unit of analysis at the country-level.

1.2 Statement of the problem

The problem is the scientific and technological backwardness in developing countries. Eritrea is no exception to it. It is, in fact, more pronounced in the case of Eritrea for the simple reason that it has recently emerged from the 3O-year war of liberation, the industrial base left Introduction and Theoretical Framework in Eritrea by the Italians was very promising. In the early 1970s it accounted for about 40% of the industrial output of Ethiopia. But the 1952 UN resolution to federate Eritrea with Ethiopia led, first, to the deliberate policies of "slow down and dismantle" of the industrial base of Eritrea. Next, the protracted war of liberation killed any possibility of industrial growth and economic development. In fact, the reverse is true. We have witnessed a process of de-industrialisation.

Today those few industrial enterprises that managed to survive almost three decades of stagnation and decline are on the verge of complete bankruptcy because of the old and obsolete technology, lack of skilled manpower, managerial capabilities, and financial difficulties. Therefore, it is not possible to talk in terms of an industrial technology base of the country. If we look to the government of Eritrea as an institution, let alone the establishment of S&T policy making body, even the major ministries have not yet got a complete shape themselves. The government as a whole is in the process of formation.

Any way Eritrea is like "tabula rasa" that can take the shape its leadership is able to give it. It is possible to say that there is no past commitment that hinder a new direction and a new commitment for a long-term industrial technology development. This is, in fact, what makes at this point in time very crucial to design carefully an industrial technology policy that can enable the country to progressively build on S&T base for a strong economy in the coming decades. We believe that the mastery of IT is going to play a determinant role in this process.

The Eritrean government in its Macro Policy has clearly stated that Eritrea is going to be a service-hub in the region, that is, the service industry is going to play the dominant role in the development of the country. Financial institutions and other services are definitely going to be the major protagonists. In an era of "electronic fund transfer" it is not possible to have banking or insurance services not based on IT and be of international standard. Therefore, S&T policy should determine all the priorities and prepare the framework within which all relevant internal and external institutions can work to develop a sustainable industrial technology. Particularly the IT policy would be of great relevance to the financial institutions, trade, tourism and other social services because it would make networking possible and easier. Moreover, it could enhance the global connectivity of the country through Internet.

Governments in the developing countries have been always tempted to buy every new technology, which is produced in the developed countries. But most of the technology developed in these countries has little direct relevance to the problems confronting many developing countries. In fact, "Research on problems directly relevant to the third world probably accounts for little more than one percent of the total research expenditures of the industrialised countries" (United Nations, 1981: 3-46). This is an additional reason why developing countries should look into developing their S&T infrastructures.

The present Eritrean government, since the years of liberation war, has been following and is still committed to the policy of self-reliance. There are quite a number of successful attempts to adapt and make effective use of technology in the history of the Eritrean people. Those lessons must not be forgotten but should be systematically studied in order to develop right strategies and policies for the future.

At a time when every good and service has a considerable content of information and knowledge, developing countries cannot continue to assume it is still safe to work on the old paradigm on which the classical economics is based. The world has completely changed and is rapidly changing. In the new global economy, only the countries taut are capable to produce and sell information and knowledge intensive goods and services will in the long-run survive. The tool to do this is S&T and innovations. Developing countries are at disadvantage at this particular time because their S&T as well as innovation capability is very low (or backward). How to redress this unfavourable situation? This is mainly the objective of this research.

The main question of this research, therefore, is how Eritrea can transfer the relevant S&T in particular II, for a successful transformation of its economy and its society and avoid being at the fringe of the new global economy. By 'transfer of relevant S&T' we mean the acquisition of mature science and technology, the assimilation of it and possible adaptation and improvements. This is based on Kim's model and is expanded in chapter 2. This main question has been divided into two sub-questions:

1. What is the state of S&T policy in developing countries and, in particular, how are the developing countries managing their IT to avoid future costly dependencies?
2. How can Eritrea exploit the opportunities offered by IT to strengthen its economy based on the experiences of other developing countries?

Note that we have chosen an integrated approach rather than studying IT alone. We believe that in the case of Eritrea addressing the broader issues of S&T are very central on how to best place IT vis a vis the other technologies. After all IT is only a subset of S&T.

1.3 Objectives of the research

The major objectives of this research are:

1. To understand the difficulties encountered by developing countries in the process of economic development in limiting their technological dependence.
2. To develop a model of an effective S&T base development for Eritrea based on the above understanding.
3. To develop a plan for a sustainable IT base for Eritrea.

1.4 Organisation of the study

This research is organised into three parts and 14 chapters. The first three chapters consist of the introduction dealing with the study background, statement of the problem, objectives of the research, and the organisation of the study, the theoretical background and research framework and research methodology.

Part I deals with S&T at the forefront of developing countries, the Newly Industrialised Economies (NIEs). It goes over the experiences of the NIEs in Southeast Asia and Latin America to capture their experience and learn from them. This part is considered to be very important in a research like this because some of these countries have almost achieved their dream of catching up the developed world, at least in per capita income. How this achievement was possible is a very important link that will be needed at the solution stage for the Eritrean case" It discusses the broad S&T development of Singapore, South Korea, Taiwan, Hong Kong, Brazil and India first; and then focuses on IT development and use in only Singapore, Brazil and India. It ends with conclusions and lessons learned from these NIEs.

Part II focuses on the Sub-Saharan African (SSA) countries in general to come closer to home. Following the same structure of Part I, it tries to give the common major traits of SSA countries in their effort to master S&T in general and IT in particular. This part ends also with the major lessons learned from SSA countries. And finally, Part m deals with the case of Eritrea in the same fashion. The first part and the second are inter-linked in the sense that Eritrea is trying to learn from the success and failure that has been experienced in the whole world of the developing countries. Since there is not much achievement made by the SSA countries in terms of S&T for development, Part I tries to give the missing link by turning to countries that where at the same level, more or less, four decades ago but achieved a tremendous progress. All of these will form the groundwork and the context on which all the analysis of the study of 'IT in Eritrea' will be based. And from the best practice, a framework for S&T policy and management for Eritrea has been developed. Within this framework, a model of IT Plan as an infrastructure for the Eritrean socio-economy development is constructed.

To a casual observer, the discussion of S&T policy and management seems to be out of place or less relevant to a research on IT. But in the case of Eritrea, where previous experience on S&T policy making and management is absent, it would automatically become a deficiency that may create some gaps later on. On the one hand, IT is a sub-set of S&T in general. On the other hand, without good S&T infrastructure it would become more difficult or even impossible to develop II in isolation from other technologies important in any process of development. Therefore, in each part the first chapter deals with issues relevant to S&T development including that of IT.

Part I and II explore the literature in order to choose an appropriate model for S&T policy in the developing countries. The structure followed is that of the top-down approach. This is because governments have always played, directly or indirectly, a central role in S&T development in the developed countries, particularly Japan and in the newly industrialised economies, South Korea, Taiwan and Singapore. Similarly, governments' direct intervention in the economies of -insignificant the SSA countries are pronounced. But it was most of the times with success. Government willingness to commit appropriate budget for the development of infrastructures, models of inter-sector co-operation, and appropriate technology transfer mechanisms is a determining factor to strengthen the industrial technological base. In the case of Eritre4 the government has started to play a leading role in the economic development and it is expected to continue in the foreseeable future.

Therefore, the whole structure of the research revolves around a general exploration of the socio-political and economic environmental context and then moves to the discussion of S&T policies and management followed by human resource development and institutional capability issues. Side by side IT has been separately treated because it is the research focus. We have also tried to focus on Singapore, Brazil, and India to make an in-depth study of IT. Singapore is selected because it is considered the closest possible model for Eritrea. While Brazil and India are selected because they can give a different picture, which can enrich our understanding of IT in developing countries, including the big countries in Latin America and Asia. It can more or less be considered like a continuum between small and large countries and between open market and relatively closed ones. Therefore, in the whole research the technology of focus is IT, At the end, the answer will be given on how Eritrea can leapfrog using II as an infrastructure to a new socio-economic structure in catching up in S&T and get out of the margin of the global economy.

In the concluding chapter, the research paper proposes a model for the establishment of S&T policy-making body and in particular suggests a viable IT policy for Eritrea. The policy implications that follow from the study can help the country to progressively reduce the dependency on foreign technology and expertise. A plan that deals with the setting up of technological priorities and building up of indigenous technological capability is suggested. S&T policy instruments, from planning to evaluation of performance by various institutions, and their integration to the objectives of the national development plans will be the yardstick throughout. The gradual build up of the national potential in IT to support the Eritrean financial sector, transport and communications, trade, tourism and social services will be elaborated.

2

2. Theoretical Basis and Research Framework

2.1 Introduction

To develop theories that consistently explain the different phenomena of our world is the main activity of our scientists. Economists do this kind of work to explain the optimal use of scarce resources in the wealth creation of nations and its distribution.

If we try to make sense of the different theories and models of economic growth, we learn quickly that we are in a big jungle and one can easily be lost. One of the main difficulties encountered by social scientists is, for the sake of objectivity and precision for example, they invariable go to the world of mathematics for help. But this has its own problems. The mathematical language is very concise and precise, but expressing the social and economic life of mankind in mathematical terms is not always possible. It goes without saying that models are always a simplified representation of reality. They want to represent only the most salient characteristics of the subject of study. To start with, the major variables that explain a particular phenomenon have to be determined by the researcher before the mathematical relationship is expressed, each researcher has his specific angle of observation of the given phenomenon. A number of things have to be assumed, hence, the proliferation of models and as a result a 'jungle of theories' that want to explain the same phenomenon. The same can be said of all the other research methodologies and models. Some of the theories are complementary while others seem to be mutually exclusive.

Let us use an analogy to explain this. Let us say you are in a valley. What you can observe will be confined to the valley itself, which is limited by the surrounding hills and mountains. If you go higher on the top of a hill, you can see a bigger area, may be, a number of other nearby valleys. If you go up on the top of the mountain, you can see a very vast panorama with a number of hills, plains, rivers and valleys. If you higher in a plane, you can see a whole region. Try to be with the astronauts out on the orbit. You see the whole of the earth like a smooth small ball. Assume you still go further. You could see the whole solar system.

The interesting point here is that when you were in the valley you could observe every detail: the running streams, the trees with their beautiful green shining leaves, the singing birds on the trees of different size and colour, the grazing sheep, the singing shepherded, etc. When you went up to the mountain top the beautiful sight you had in the valley disappeared. Now you have a completely different sight. The furthest point you could see is green and brown patches, the white dots on the hill's side that you recognize as the sheep, waterfalls like cotton white etc. From the plane everything is gone except smooth shaped mountains and valleys. At the same time new scenery is emerging, that of a region. You see a number of villages and towns some deep down in the valley others at the top of the hills or the side of the mountains. The one you see when you are out in the orbit: out earth looks like a small ball and together with the other planets going around the sun, is also another breathtaking sight.

Similarly, the theories we have are many because some are the result of different angle of observation and others are the result of different interpretations of the same phenomenon from the same angle of observation. The first group is complementary to each other and enriching but the latter at times are confusing. It is enough to observe the literature with regard the success of the East Asian NIEs. Some attribute it to free market economy system they have followed, others to the careful intervention of governments to guide the economy, and still others try to find explanations in the culture of the people and their work ethics. When you come to the failure of the SSA countries some look to the colonial legacy for explanation others to political instability and corruption of governments and still others to changes in the world economy and the debt burden. There is not a general consensus. Different authors coming from different economic thought give opposite interpretations of the situation and conclude with different policy prescriptions.

Coming to economic growth (technological change) theories, great contribution has been made from all sides, neo-classical or neo-Schumpeterian. We have a better understanding of many things thanks to these studies. But we don't still understand why few enjoy excessive wealth while the majority are still afflicted by extreme poverty, ignorance and diseases in this world where, at least theoretically, we are all equally created and all the earth's resources are of all of us.

This research and its framework have been influenced particularly by the neo-Schumpeterians we can clearly see from the following sections.

2.2 Theories on technology and economic growth

Let us start from the definition of the key words. The words 'science and technology' are among the most widely used, revered and idolised of our modern times. They seem to have promised mankind everything: to master his environment and his destiny. Only when you ask yourself whether science and technology deliver such promises, then, it becomes clear the complexity of the subject.

These two words usually go together and it is hard to define their respective boundaries. But one thing is immediately clear, that there is a lot of semantic confusion around them. This research does not want to embark on such a task, but it is only fair to start by making clear from the beginning what the word 'science' and 'technology' stands for, at least, in the context of the present research.

The word 'science' is frequently used to mean 'objective' or 'exact' or 'rational'. For example, if someone tells you 'this is science', you understand that he/she means that it is something observed carefully, experimented, and replicated and found true. In other words, it is objectively so. It is not a subjective judgement based on intuition or feeling. Webster's New World Dictionary defines science as "systematised knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principles of what is being studied". Therefore, science tries to explain the natural and social phenomena. The scientist studies the different social and natural phenomena to explain them. Any study to qualify as scientific must satisfy the so called scientific criteria: (1) careful observation of phenomenon, (2) formulation of a hypothesis to explain the observed phenomenon, (3) making of sufficient number of experiments to study the phenomenon, and (4) reporting the finding possibly with systematic explanatory theories. The methodology is highly emphasised for reasons of replication. Once a finding has been replicated enough times and found to be sound it is included in the body of scientific knowledge. This is in short how the scientific knowledge is created.

Coming to technology it is variously defined such as 'science of industrial art' (Concise Oxford Dictionary). This definition leaves one with more questions than answers. Stuart MacDonald (1983) said that people think that 'technology' is something to do with machines. The more complex the machine the higher the technology associated with it. It is difficult for people to think of technology without machines. But he argues that it is quite possible for technology to involve no machines at all. He gives the example of crop rotation as a technology, and he continues that it was probably more significant in Europe during the eighteenth and nineteenth centuries than any other scientific discovery. By the same token, he goes further to view change in administrative or managerial practices as technological changes.

It is an interesting argument, but why not go beyond the machines? After all a machine is only a tool. The skills of the people that designed and manufactured it as well as the skills of those who operate it are very crucial. The co-ordination and direction of hundreds of such skilled individuals and machines also is far more important to get the benefits of any technology. Therefore, why keep the machines in and the skills of the creators and operators of machines and the skill of managers out? Today, we have the software technology, which is the fastest growing sector in the IT industry. It is a revolutionising technology without machines. Since we are focusing on II, we will give the definition that we attribute to it from this research point of view after we finish the general definition of technology.

Let us take some more definitions. 'Technology is a method for doing something. Using a method requires three elements: information about the method, the means of carrying out, and some understanding of it' (Dahlman & Westphal, 1983). This means that a machine by itself is not a technology neither the information of how the machine works without the machine and someone that understands it. There is no technology without machines, information and people that understand it. The definition given by Laseur (1991) is more suited to manufacturing industry. Technology is the knowledge and skill necessary for the conversion of raw materials and semi-manufactured goods into products of which the value is _greater than of the basic materials. There are three carriers of knowledge and skills called: (1) hardware (machinery, materials), (2) paperware (manuals, prescriptions, computer programs), and (3) humanware (knowledge and skills in the brains and hands of people). These carriers are not always present in the same proportion. They are only present in a ratio, which depends on the specific technology at hand.

Therefore, it is possible to give a broad or narrow definition of technology. Here we will use it both ways to explore the firm or country level technological capacity development. Thus, together with many other authors, we say that 'Technology is the application of scientific knowledge and skills to the setting up, operating, improving and expanding of productive facilities. However, it can be narrowly defined to cover the technical aspects of such applications, or broadly to include managerial, organisational and other aspects' (see Dahlman & Westphal, 1982; Fransman's introduction to Fransman and King, 1984; Teitel 1981, 1984). But it is not meant to imply that technology is always the result of systematic scientific activity. We acknowledge that we can have technology independent of science. In this paper, because we are dealing particularly with information technology, we think this definition is the proper one. With MacDonald (1983) we can say that ,technology can be regarded simply as the way things are done, and technological change as the adoption of what are thought to be better ways of doing things'. 'The way things are done' includes machines, materials, information, know-how, skills, management etc. If this is so, it goes without saying that the success of any technological change will depend very much on how well balanced and integrated all the parts of the technological package are. And this role is one for management.

When we come to science in relation to development, we can see it from different approaches. One of these approaches is known as 'science/technology push model' (Bush, 1945). Bush sees basic research as the engine to innovation. He said that "New manufacturing industries can be started and many older industries greatly strengthened and expanded if we continue to study nature's law and apply new knowledge to practical purpose. But to achieve these objectives - to secure a high level of employment, to maintain a position of world leadership - the flow of new scientific knowledge must be both continuous and substantial." At the same time, in his view, "Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploitation of the unknown."

Another model of innovation is the Market Pull Model. This is based on the idea that innovations are an outcome of interactions between market needs and basic research; the steps in between i.e., applied research, technology development, and implementation fills in the gap (Bhalla, 1987). It is the reverse of the Science/Technology Push Model.

Given that scientific and technology development activities depend on the work of people, the challenge is to motivate scientists and technologists. This can be best accomplished by providing realistic challenge, direction, and an open environment with strong technology leadership. CEOs should show the same zeal for technology as they do for financial performance and be willing to take on the task themselves rather than delegate it (p. 85).

Technology, therefore, operates parallel to science and functions both as contributor to scientific development and as beneficiaries of scientific accomplishment. But technology itself can be broadly divided into two parts, technology development and technology implementation. The first is a stream of knowledge translated into physical "hardware/software", which will eventually meet with some human use. The second, technology implementation, is a much more general form of combined activity in which the ideas of science and the hardware/software of technology are actually put to some use in the socio-economic world environment (Allen, 1977).

This century saw the emergence of science and technology as an institution. This is to mean that huge number of research institutes, public and private, are established everywhere to produce science and technology. This is because the idea that science is the foundation of any innovation, Bush's idea, was widely accepted. But when the question of whether or not every dollar spent on basic research is generating the expected number of innovations, the result is at best mixed. One thing is sure. Research expenditure is not directly correlated to the number of innovations because innovations are not the direct result of science but of its creative use. For that matter, even technology is not necessarily the direct result of science. Sometimes technology precedes science. We discover new techniques before we could explain it why it works. Then, science is called upon to find out the underlying principles. Therefore, it is not necessary to keep an absolutist stance for one way or another. May be it is productive to keep balance between the two extreme positions of seeking science for the sake of pushing the frontier of knowledge only and the other of looking for immediate solutions to social and economic problems without understanding the long term effects of our actions.

Today, it seems that stressing the function of science for national competitiveness and allocating resources to university-industry collaborations and critical technologies is the dominant trend (Slaughter and Rhoades, 1996). The 'free play of free intellect' concept that has dominated in the past is increasingly questioned. In science policy debates, a lot has been written for and against the two trends. But in practice the two intertwine and make up the fabric of institutional structures, of frameworks of rules, procedures and arrangements, to prepare, implement and perform policies (Braun, 1993; Balmer, 1996; Kleinman, 1994; Van der Meulen, 1998).

Studies about the origin and diffusion of new technologies are very important to understand how they affect economic growth. Schumpeter calls them 'the gale of creative destruction' and considers them as the essential ingredient of capitalist economic development (Schumpeter, 1943). Entrepreneurs and innovators are incompatible with equilibrium, but the disturbance represented by the intrusion of innovations into the economic system gives a new impetus to economic development. Coombs et al (1987) tell us that in Schumpeter ideas there are the seeds of three of the four central questions or hypotheses about the origin of innovation. First, whether the central character is the entrepreneur or the large firm, it is only by introducing radically new ideas into economic life that the whole new industrial sectors can be generated. Technology, whether generated outside the economic system or in the large R&D laboratories of a monopolistic competitor, is the leading engine of growth. Therefore the 'technology push' hypothesis of the origin of innovations finds a natural place in Schumpeter's ideas. The second question is if whether more and better innovations produced by many entrepreneurs or by few large oligopolists? Or, in other words, what is the ideal market structure to stimulate innovation? The third question, for which Galbraith should be perhaps be credited more than Schumpeter (Kamien, Schwartz, 1982), is related to firm size: what is the best firm size to stimulate innovation? The fourth hypothesis is generally attributed to Schmookler (1966), fluctuations in investment could be better explained by external events than by the course of invention and that, on the contrary, upswings in inventive activity responded to upswings in demand. Because of this Schmookler has always -been referred as the exponent of a demand-led theory of innovation. Even though, he was trying to correct the opposite imbalance according to which it was only the exogenous flow of inventions which could generate new investments and new economic activities.

In the immediate post War II period the belief that only pure science could generate a self-sustaining economic growth was expressed by many policy-makers, for example Bush, 1947, which was challenged during late 1960s and early 1970s. Neither technology-push nor demand-pull is found to predominate systematically but each one of them can lead the other at different stages in the development of the industry. If any generalisations can be made, technology-push tends to be relatively more important in the early stages of the development of the industry while demand-pull tends to increase in relative importance in the mature stages of the product cycle (Freeman et al 1982). Therefore, neither the idea of Schumpeter nor that of Schmookler is adequate alone. A combination of these ideas seems to explain better the development of these industries. Furthermore, Burton (1999) suggests that the neo-Schumpeterian economists have not been able to clearly articulate how firms search and innovate, or provide any guidance on the organisational processes involved. He suggests a post-Schumpeterian framework with crucial four elements: (i) knowledge creation within the firm, (ii) knowledge protection by the firm, (iii) collaborative business arrangements for knowledge creation, and (iv) the notion of diffused entrepreneurship.

In this research, there is one particular idea of Schumpeter and his followers in which we are interested. It is the idea that clusters of innovations do occur. In particular the very process of diffusion of an initial innovation, if it was of sufficient importance, would generate further related innovations because the 'retinue of imitators' would tend to improve upon the first innovation and to create other innovations in related products, processes, technologies and organisational structures (Schumpeter, 1964). The view of exactly what is meant by a 'cluster' of innovations has been developed to a greater degree of clarity by Rosenberg (1976, 1983) and Freeman (1984).

An alternative account which is centred on the concept of 'New Technology Systems' (NTS) has been given by the followers of Schumpeter (Freeman, Clark and Soete, 1982). There are two essential features of the NTS ideas, which differentiate it from a cluster of basic innovations. Firstly, it consists of technologies that are very widely applicable in many products and processes in many industries, thus generating a range of related innovations. Secondly it is argued that it is the clustering of diffusion processes for these innovations rather than clustering of the dates of the innovation themselves which is both the appropriate interpretation of Schumpeter's position and the most important stimulus to the long wave upswing. For the post war boom of the 1950s and 1960, these authors presented substantial case study material to support the view that this role is played by two such technologies: synthetic materials and electronics. These satisfy also the technically related clusters (T-clusters) and the non-technically related clusters (M-clusters) requirements laid down by Rosenberg and Frischtak (1983).

Economists have pointed to the importance of 'technological trajectories' (Nelson and Winter, 1977) and of 'constellations of innovations' (Keirstead, 1948), which are both technically and economically interrelated. Several have also extended Kuhn's (1961) notion of scientific paradigms to the concept of 'technological paradigms' (Dosi, 1982). Nelson and Winter (1977) also suggested that some trajectories could be so powerful and influential that they could be regarded as 'generalised natural trajectories' (electricity). However, Carlotta Perez (1983) was the first to take these scattered ideas and comments and relate them not just to a particular branch of industry but to the broad tendencies in the economy as a whole. Her theory may be described as a 'meta-paradigm' or a 'pervasive technology' theory. In this way she gave some real content to the notion of 'successive industrial revolution'.

A change of techno-economic paradigm or 'technological style' brings with it a whole range of new products and processes and many others which are redesigned to take advantage of the new technical and economic possibilities. Perez suggests that underlying this paradigm change is not just a range of new products but a change in the dynamics of the relative cost structure of all possible inputs into production. She maintains that microelectronics has clearly perceived low and rapidly falling relative cost, almost unlimited availability of supply over long periods, and clear potential for the use or incorporation of the new key factor or factors in many products and processes throughout the economic system. Few would deny this. It held until recently for oil, which underlay the post-war boom. The new key factor does not appear as an isolated input, but rather at the core of a rapidly growing system of technical, social and managerial innovations some related to the production of the key factor itself and others to its utilisation. Gradually the new model of innovation affects all sectors of the economy (example the chemical industry, Freeman 1990). It embodies three main features (Perez, 1985) in the case of new information technology paradigms:

l. Information-intensity rather than energy-intensity in products and processes. In the case of Japan this shift has been studied and confirmed by a number of researchers (Freeman, 1987).

2. Flexibility in process investment and in product mix rather than the dedicated capital equipment and standardised products range characteristic of the 'Fordist' mass-production system.

3. 'Systemation' not just 'automation'. Fordist production systems already used automated production equipment and process plant. The new paradigm uses information technology and communication technology to integrate the production plant with the design, marketing and administration functions within the firms.

In the same vein, Freeman (1988) gives us an analysis of change in labour productivity and in capital productivity over the past 20 years at a sufficiently desegregated levels which bear witness to the tremendous impact made by microelectronics in most sectors of the economy (see Appendix 1). It again clearly transpires that IT is a very pervasive and revolutionary technology. Moreover, the promotion of generic technologies, especially information technology, has become a regular feature of technological policy and industrial policy in almost every member country of the Organisation for Economic Co-operation and Development (OECD) in the course of the 1970s and 1980s. The extent to which such efforts are successful will depend not simply on the scale of resource, which is committed in the public and private sectors of the economy, but also on the 'national system of innovation'.

Given that our research is a country case study, a theory that can integrate all the major factors to scientific and technological innovations is of great help. Besides, in developing countries the major systems essential for the development of local technological capability exist in virtually all of them, but a coherent system of relations among these systems, which would have the effect of making them complementary to one another, is what missing (UNESCO, 1988, p48) is. The closest to this is the concept of 'national innovation system'.

This was articulated initially by Lundvall (1985, 1986, 1992) and Nelson (1993), and more -recently by Edquist (1997). It reflects the perception that government, firms, universities, research laboratories, the financial system, and a host of institutions take part in the process of knowledge accumulation, particularly as it is reflected in producing innovations. The actions of these key institutional players and the interaction between them determine the impact of innovation, and more generally of knowledge, and the well being of nations. The national innovation system perspective acknowledges the specificity of each country, defending country- and time-specific policies to harness the benefits of knowledge to economic growth. Nelson suggests that the use of institutionalist frameworks such as the one proposed famously by North (1990) might be valuable in gathering the amount of diversity inherent to an approach that tries to account for the diversity in national innovation systems. In line with this, our research can be viewed as a research that acknowledges the specificity of each country and is looking for country- and time-specific policies for Eritrea in search of knowledge for socio-economic development.

We believe together with Freeman (1987) and many others that 'catching up' cannot be assumed as an easy and almost castles process because new technology is considered to be equally and freely available to all comers (assumption made by perfect competition theory). The findings of empirical research on the dynamics of technological competition are virtually unanimous in pointing to availability of skilled manpower, of institutional capability to support development, of infrastructure investment and of work culture and networking as the basis for technological development and innovations. For example, Freeman (1987) believes that Britain in the first industrial revolution, United States and Germany in the late nineteenth and in the twentieth century, and Japan in the second half of the twentieth century succeeded because of major institutional changes in the national system of innovation. This is based on the new ways of organising the processional education of engineers and scientists and of organising research and development activities as specialised departments within firms, and employing the graduate engineers and scientists. Freeman thinks that the Japanese system seems particularly well adapted to take advantage of the enormous potential of this new paradigm (microelectronics revolution), for several reasons: the systems approach to process and product design; the flexibility of the industrial structure; the capacity to identify crucial areas of future technological advance at national and enterprise level; the capacity to mobilise very large resources of technology and capital in pursuit of strategic priorities.

The latest economic miracle of the NIEs of South Korea, Singapore, Taiwan, and Hong Kong basically is a replication of the Japanese success. Each of these countries followed a country specific strategy of technology transfer. For example South Korea heavily depended on the Chaebols, large business conglomerates, while Taiwan depended on small and medium sized firms, and Singapore on DFI of the multinationals. They did it through technological learning and export marketing. Hobday (1995) says that the technological role of exports is to progressively pull the learning of latecomer firms forward by stimulating technological change. He explains, through sub-contracting and other channels, export clients and export demand act as a focusing device for technological investments. Exports force the pace of technological progress and enable latecomers to overcome their distance from the demand markets from the West. And local competition stimulates the process as followers imitate export leaders.

At last, we need to explicitly acknowledge that learning is a must to transform developing countries. Technological learning is the process by which firms acquire technology. Learning is central to master science and technology and to productivity growth and different types of product and process improvement (Malerba, 1992). Technological learning is a dynamic, difficult and costly process. It involves substantial and deliberate effort and investment on the part of the firms. Learning enables firms to build up their knowledge about products and manufacturing processes, and to develop, deploy and improve the skills of their workforces (Dodgson, 1991). Learning usually involves both knowledge and experience, encompassing formal methods such as training and informal mechanisms such as imitation.

All these technological learning and catching up is important to developing countries. As Castells (1996, p.7) puts it beautifully: "If society does not determine technology, it can, mainly through the state, suffocate its development or it can embark on an accelerated process of technological modernisation able to change the fate of economies, military power, and social wellbeing in a few years. There are particular technologies, as we have seen above, that are strategically decisive in each historical period as the shapers (like microelectronics revolution of today) of the destiny of those society that have the ability to master technology". Without accepting technological determinism, Castells concludes that technology embodies the capacity of societies to transform themselves, as well as the uses to which societies, always in a conflictive process, decide to put their technological potential. Otherwise, countries remain at the margin of the global economy as is happening for SSA countries.

Before concluding this section, let us give the definition of IT from the perspective of this research. IT is variously defined by different people. Zorkoczy and Heap (1995) say that the word 'information technology' is a relatively recent and perhaps not particularly well chosen addition to the English language. There are other similar words such as information and communication technology, informatics, telematics etc. It is very import to pay attention to the context in which different people use each of these words to properly understand the writers' mind. For the sake of clarity, we hereby define IT as comprising the computer technologies (hardware and software), the communication technologies (hardware and software), and the semi-conductor technology. These industries are increasingly having blurred boundaries (Freeman, 1987; Kobayashi, 1988). These technologies are blended in various ways to give different products and services based on the digital character code. The only factor that keep them together is that they serve one major function that of collecting data, generating, storing, and disseminating information (in digital form) in various ways: text, graphic image, voice, or video information wherever it is applicable. It can be at the office, in the factory, or in the agriculture sector, or any type of service industry to simply inform or do a job. What makes this technology revolutionary is the fact that it is processing and communicating information on a real-time. It enables the communication of people-to-people, people-to-machine, or machine-to-machine. It comprises the stand-alone computer or workstation, a local area network, or the wide area network like Internet that make up our information system. Since we are studying IT from a country's perspective, we are applying it in general terms from the office automation, the design and manufacturing of goods, in the process of giving services, and in research and education wherever applicable.

The researcher believes that Eritrea does have a window of opportunity as a new comer and a new nation. It doesn't have tied up huge investments made in older technologies (for example old analogue telecommunications infrastructure). It doesn't have the chronic debt problem of many SSA countries. It can systematically build digital IT infrastructure as a base for its socio-economic development. This can enable the country to leapfrog considerably and get out of the dependency of primary product export as the main source of foreign exchange, which is one of the major problems in SSA countries. Tourism, trade and other services could -be the first to benefit from this move and serve as a basis for further industrialisation.

Therefore, it is the desire of this research to contribute on how Eritrea can build, based on the experience of other countries that were in the same position some three-four decades and have succeeded, and IT infrastructure on which its socio-economic structure could be based. This is based on the assumption, as we have argued above, that information technology is a '*sine qua non'* tool in every sector in the future.

2.3 The issue of 'appropriate technology'

It is very important to raise the question of whether or not 'information technology' is too advanced for the developing countries to contemplate in investing in it. Even if they embark on it, will there be any significant contribution to the development of their economies and the solution of their social problems?

At one time there was a lot of 'appropriate technology' debate in the literature. Many have suggested that developing countries need a technology that is labour intensive. The argument goes, since new advanced technology is capital intensive, it is not appropriate technology for the developing countries. By the same token, we could say the same for information technology and exclude it from the technologies to be chosen. But we are not nether eliminating the long-term technological dependence of developing countries nor the danger of exclusion from the global economy by promoting appropriate technology which is mainly designed to improve life of the rural people.

The logic of the appropriate technology debate was particularly based on the fact that developing countries are rich in unskilled cheap labour and they lack the capital for investment. Going for 'appropriate technology' or 'intermediate technology' which is simple to use and maintain, and at the same time creating more employment, would be more advantageous, But it fails to answer how these countries will graduate from being 'underdeveloped' to the status of the developed nations, which is their aspiration? How can the goods and services the developing countries would produce with this 'intermediate technology' be competitive enough to be exported to allow them to make the foreign exchange for their imports? Or else, the economy will be introvert and closed and lead to more isolation from the international trade and thus stagnation of the economy.

On the other hand, how do we evaluate technological appropriateness? Do we mean only labour intensive? Do we mean only to the technology that uses the available low skills and local materials for local use? If we see the appropriate technology ideas (Schumacher, 1973; Weaver and Jameson, 1981; Dunn, 1978), it is not difficult to observe that it was focusing on the rural economy. The possible advantages sought were, first, to create employment in rural areas where most of the people live; to use local skills, materials, and financial resources, thus leading to lesser dependence on external sources. Second, it wanted to maximise use of renewable resources, to be compatible with local cultures and practices and to satisfy local needs and wishes. These ideas can help in the short-term but cannot serve the long-term interest of a developing country. Even the rural communities for which these appropriate technologies were designed have to be educated to liberate them from all their social and economic ills in the long-term. With the necessary investments in education, the need of these appropriate technologies decreases as education increases the skilled manpower poof. These educated people could not be happy with the quality of life offered by the rural communities (or the slums in big urban areas). There is no reason why with skilled manpower modern technologies cannot be used. It is the only way of integrating the urban economy and the rural as well as to the global economy. Of course, a careful balance need be maintained between investment in new technologies and their sustainability.

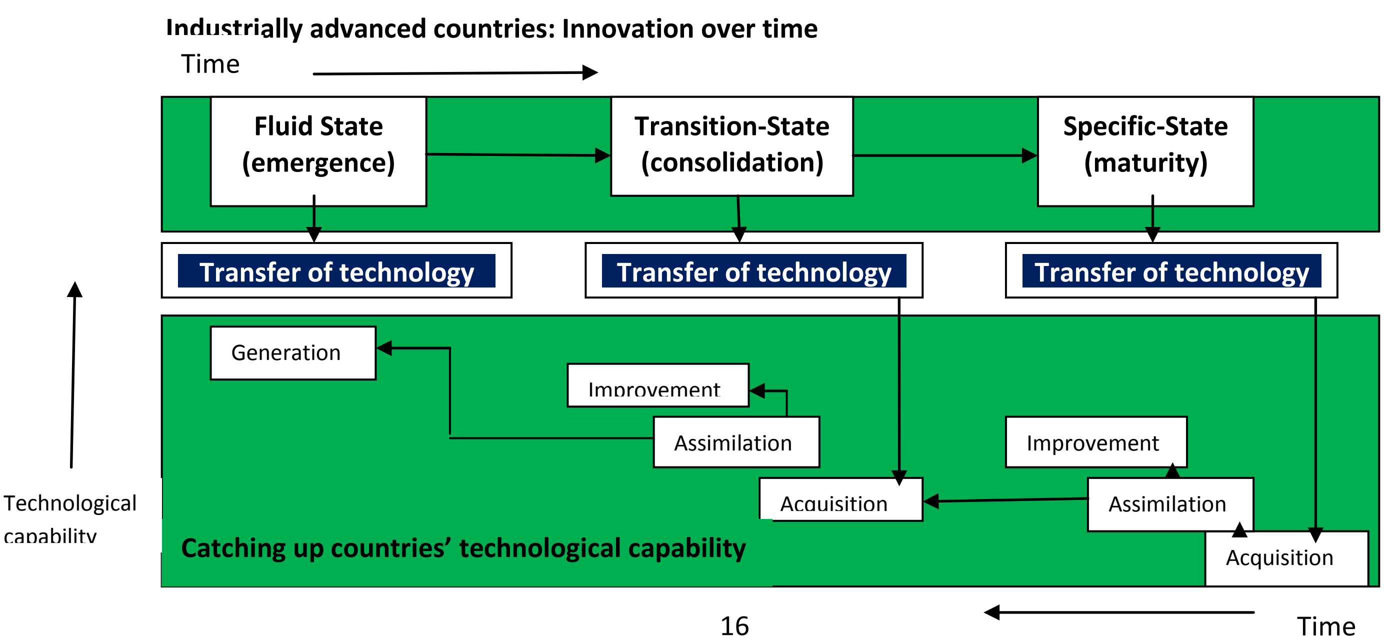
In the case of Eritrea, for example, 70% of the population lives on subsistence agricultural economy. Drought, poor crops and famine have repeatedly hit the country. There is no way that small improvement can change the life of the farmers waiting for erratic seasonal rains. A breakthrough is required with a modern farming technology. A progressive transformation is required. This entails scientific water and soil conservation systems, irrigation systems based on underground water and a network of small dams and drip-irrigation systems for water is scarce in Eritrea, etc. All of these to work need institutional support in diffusing and supporting the new technologies and access to markets. At a time when the subsistence farming is no more sustainable because of deforestation, soil erosion, expansion of deserts and population explosion, small intermediate technology that exploited local knowledge, resources, and techniques are clearly inadequate. But till the time people are educated and trained for the required transformation to occur (intermediate period), useful ideas of intermediate technology can always be employed where ever applicable.

Together with Peter Loh et al. (1998) we believe that the assumptions that low-tech, labour intensive operations are always the most appropriate is incorrect. It may be correct for some developing economies and some production sectors, but wrong for others. It would be foolish to employ a particular level of technology across the board in all sectors of the economy. Developing countries, therefore, have the opportunities of blending local traditional methods with modern science and technology. Particularly information technology has a tremendous power of multiplying expertise and pushing upwards the productivity of people of intermediate skills and thus could be easily blended with the traditional way of life in developing countries.

2.4 Leapfrogging Possibilities

Now developing countries are mainly dependent on the export of primary products for their foreign exchange earnings. But this earning is decreasing with every passing year. This is due to the decreasing trend in prices of primary products in the international trade. The international trade is biased towards the high value-added products. It is clear that these countries cannot depend any more only on these primary goods export. Therefore, industrialisation based on science and technology seems the only left way out. To compete on equal footing with the advanced countries in the international market, you need the same or comparable technology that they have. It is like the strategies followed by the NIEs. How do you go about it?

Figure 2.1: integration of two technological trajectories (adopted from Kim, 1998).



Kim (1980), departing from the patterns of industrial innovation of Abernathy and Utterback (1978), gave a three-stage model of technological trajectory in developing countries based on the experience of South Korea: acquisition-assimilation-improvement.

Developing countries are trying to catching-up by first acquiring mature foreign technologies. These technologies are quickly diffused within the country at a second stage. And at the third stage, these acquired and assimilated technologies are improved through local R&D to adapt them to different product lines. Jinjoo Lee et al. (1988) have proposed an integrated model of Utterback and Kim and postulated that the three-stage technology trajectory in developing countries takes place not only in mature technology in the specific stage, but also in growing and emerging technologies in the transition and fluid stages.

Kim and Dahlman (1992) went beyond the two technological trajectories to suggest the integrative framework, which adds the market mechanism dimension to it. This framework is comprehensive and complex at the same time but it tries to capture reality closely more than other models. Therefore, developing countries can be viewed as struggling in the process of catching up the advanced countries as presented in the Figure 2.1 above. It is a moving target. Those who will have the determination to mobilise and effectively manage their skilled manpower, imported technology assimilation and diffusion with the co-operation of government and market forces, there is hope in the coming decades for them to see the light at last.

Today the production of goods and services is increasingly using information technology. It is playing a major role as industrial infrastructure and as an industry. Therefore, it goes without saying that the least developed countries, like Eritrea need to pay attention to it. Otherwise 'catching up' will be not only difficult but also impossible. Woherem (1993) says that information and knowledge and their effective use lead to high standards of science and technology, which in turn lead to economic, industrial, political and military power and to exploitative and competitive power over other nations. In his view, developing countries cannot afford to let 'the train of the IT revolution pass them by'. There is a correlation between the possession of the ability to control and exploit the environment for economic goods and for other purposes, and the standard of living and general level of economic development of a society. Mostly science and technology provide this ability for the control and exploitation of the environment. Information technology is increasing the pace of scientific and technological development. It follows, therefore, that the countries that have mastered information technology, the advanced and the NIEs will have higher capability to develop science and technology. This will increase the existing gap in science and technology between the developed and the least developed countries making the dream of catching up impossible.

Some authors have argued that information technology is a good opportunity for the developing countries to 'leapfrog' some of the stages of industrialisation. Antonelli (1991) says that the debate on international diffusion of innovations has undergone a transformation since the appearance in the 1980s of a "macroeconomic" theory of diffusion. Japan and Italy's example of catching up with and leapfrogging older industrialised countries like the United Kingdom has pushed many economists to re-examine traditional views of economic growth and technology diffusion. Growing empirical evidence shows that for many new technologies diffusion in fast-growing imitating countries has been quicker than in innovating ones' A path breaking study by Soete called attention to the role of investment and the age structure of existing capital goods (Soete, 1985). In his perspective, late-industrialising countries with low amounts of past investment and high level of present investment have a good chance to leapfrog technological leaders, both users and producers, to adopt innovations. As Soete recalls, such a process was at the heart of rapid expansion of the Japanese and Italian economies whose eventual leadership in the sectors of steel, automobiles, electronics and numerically controlled machine tools grew chiefly from imported technology.

Catching up, says Antonelli, can lead to leapfrogging, particularly when the new capital goods incorporating the technological innovation cannot be added piecemeal to existing ones, but require the scrapping of all pre-existing capital stock, regardless of its age structure. This implies that imitating countries can adopt innovations earlier and faster than innovating countries, owing to the better investment opportunities and profit potential inherent in the young age of their capital stock. Consequently leapfrogging possibilities are especially important for countries that start out with significant amounts of capital goods and they are obliged to "start from scratch".

According to Antonelli (1991) advanced telecommunications is also typical in its leapfrogging potential for less advanced countries and the ripple effect it produces within a country's economy. The rapid modernisation of such strategic infrastructures as telecommunications has enormous advantages for the manufacturing and service industries. In fact a wave of technological and organisational innovations that enhance economic growth and set the stage for a variety of information and communication technologies is expected to enter countries equipped to receive it. Increasing empirical evidence shows that innovations based on "complex" technologies display diffusion patterns quite different from those within simpler, "self-contained" frameworks (Frankel, 1955). Innovations in elaborate systems like the new information technologies, with interconnections between telecommunications, computers, software, etc., and which demand "learning by doing" and "learning by using", tend to be adopted only after the entire technological network, each innovated component in place, has been assembled and evaluated (Antonelli, 1986). These cumulative technologies are viewed with a "wait and see" attitude and are rarely adopted before the formation of "critical mass". Once followers decide to go ahead, they can start from scratch and side step the problem of an older, depreciating technical system.

Opportunities for technology blending are strong particularly for developing countries, which often have small-scale production by small firms in traditional "low-tech" industries (Antonelli, 1991). The building of an advanced telecommunications infrastructure, which can provide modern telecommunications services and induce organisational innovations, is therefore a powerful factor in the economic growth of all countries, both developing and industrialised ones. The reasons for this are the following (ibid.):

1. It will activate learning processes in the use and adaptation of advanced software, and this will create valuable "spill-over" effects of skills accumulation and tacit knowledge.
2. The installation of a universal, switching system will provide basic communications standards and protocols common to all potential users, and this will solve major compatibility problems that stem from "lock-in" effects. Lock-ins arises from the use of specialised networks based on leased lines and prevents or delay adoption of advanced communication systems by smaller firms.
3. The generalised supply of advanced telecommunications services - because of economies of scale in production - will drastically reduce production costs and consequently customers' prices. This will encourage adoption by small firms and less advanced users like rural communities, retailers, and cottage industries.
4. Extensive use of advanced telecommunications services helps form "critical mass", which radically improves the "user-value' of all communications services and thus the profitability of adoption. Not only do services become less costly, but also more importantly, the complementary hardware (from fax machines to updated electronic systems used in manufacturing and businesses) become cheaper.

The diffusion of information and communication technologies through a modernized infrastructure can have powerful effects on the entire economic system. Large-scale use of these technologies directly influences productivity, cost effectiveness and competitiveness in industries with high levels of product differentiation and low levels of unit prices. In these industries, prompt availability of information about demand trends can boost competitive advantage. This is especially true in the textile, clothing, furniture, shoe and leather industries. Growing evidence suggests that the international competitiveness of the textile, garment, toy and consumer electronics industries in Taiwan and the Philippines relies increasingly on advanced telecommunications services, which allow tight links to form between commercial distribution on American and European markets and local production.

Moreover, information technology appears to offer opportunities for "technology blending" (Antonelli, ibid.) to advanced telecommunications system users through capital-saving and organisational innovations as in the case of users taking advantage of: more access to mufti-sourcing to compare prices and services (as with the French Minitel system); global scope of procurement of products and services; enhanced customisation of large-scale production; increased flexibility of production processes - more products can be made with the same equipment; reduction of stocks of intermediate products because of 'lust-in-time" methods of manufacturing, which allow production to take place upon the placement of the order; reduction of stocks of final product; reduced delivery time; less working capital; less invoicing delay; telephonic franchising and retailing.

These organisational innovations, as explained by Antonelli, have the following characteristics:

1. Once diffusion has taken place, the fixed costs of equipment necessary to use the telecommunications network are very low. They can be as small as the price of a minicomputer that - as is usually the case - incorporates a modem.
2. These low cost reduce adaptation barriers especially to small firms, provided the supply of the telecommunications network is available to everyone (centrally produced and distributed) and a critical mass of users of new services have already been reached.
3. Manufacturing and service industries can take advantage of organisational innovations while making little or no charges in existing equipment.

An advanced telecommunications system is also very important to service industries like banking, retailing, transportation, maintenance and insurance, where information and real-time communication are vital to the production process. A reduction in the costs of these services will indirectly enhance international competitiveness within the entire economic system, since lower market costs means lower costs for manufacturing firms exposed to international trade. The extraordinary efficiency of the Hong Kong and Singapore financial markets is more and more based on the extensive use of such advanced telecommunication services. Moreover, the integration of these countries' local tourist industries into international tourism depends increasingly on the "capillary" availability of these telecommunications services for real-time airline and hotel reservations.

Last but not least, as the growing empirical evidence confirms, the availability of advanced reliable telecommunications infrastructure are becoming important factors in affecting the decision of locations of new plants and offices by multinational global corporations. The quality, reliability and costs of telecommunications services are in fact becoming a major competitive factor for a growing number of manufacturing and services activities operated by multinational global corporations, located in a large variety of countries. The timely modernisation of the telecommunications infrastructure is thus likely to help sustain high rates of economic growth also by means of augmented inflows of foreign direct investments, and consequently, increase levels of output, employment, labour productivity and, most important spill-over of training and learning opportunities. A very good example of this is Singapore.

The modernisation of a telecommunications infrastructure is an enormous task that can be accomplished only with intensive capital investment and technical skills. For example, replacing an electromechanical telecommunication infrastructure with a modern digital one demand extraordinary level of investment. Consequently full blocks of the infrastructure have to be replaced at one time. Investment levels in electromechanical telecommunications infrastructure represent, in normal conditions, a significant chunk of gross fixed capital of a country, from 3 to 5 per cent, and from 0.5 to I per cent of GNP (ibid.). The financial effort to modernise can quickly become oppressive, particularly in countries that have fully established infrastructure. That is why they tend to delay modernisation while those countries without previous investment commitments, the late comers, jump into it to exploit the new opportunities before the advanced countries.

Leapfrogging is consistent with Schumpeter's idea of 'gales of creative destruction' which we have seen above, and the work of others, particularly that of Freeman, Perez, Dosi , Soete and Antonelli. But it has been criticised by ArehambauIT (1992) as being based only on theory than empirical research. Hobday (1995) seems to be inclined to conclude from his -studies on the four East Asian NIEs, particularly that of Singapore, that there is no leapfrogging. Hobday (ibid.) does not deny that in the area of telecommunications infrastructure many developing countries have indeed adopted digital, electronics-based systems more rapidly than advanced countries. Previously, he (Hobday, 1990, p.65) admitted at least the possibility of leapfrogging of technological infrastructure. In addition did not deny the fact that new firms may leapfrog some of the stages of accumulation gone through by the older-established firms. But he argues (1995) that digital systems are less expensive, more robust and flexible than older technologies and that older systems are out of production, therefore, developing countries had little choice in the matter. He refutes the leapfrogging hypothesis simply because technology was accumulated in gradual and painstaking manner and firms tended to enter at the mature, well established phase of the product life cycle, rather than at the early stage.

Here it is in place to clarify the meaning of leapfrog principle to avoid further misunderstanding. The "leapfrog" principle means either skipping a stage within a technology generation or skipping an entire generation of a particular technology life-cycle: discovery, invention, innovation, national dissemination, decline, and obsolescence, to arrive on the ground floor of the next one before anyone else. If we are looking for science and technology with innovation at international frontiers, we don't find much in the developing world. What we could find is adaptation and diffusion of the conventional science and technologies for the betterment of their societies. One of the commonest causes of confusion is that many economists associate technological 'effort', 'development', or 'capability' with innovation at international frontiers. In developing countries, at any rate, technological development generally denotes the introduction of a new product or superior process of production. This is certainly one important form of technological change. But it is only in a highly simplified neo-classical world that a change of the 'frontier' signifies technical progress (Lall, 1987:l).

For one reason, major technological innovations are not the only, perhaps not even the main, sources of productivity and improvement (David, 1975, and Rosenberg, 1976). From the view point of individual enterprise, the distinction between technological innovation (a movement of the frontier) and adaptation (a movement along the frontier) is largely meaningless (Nelson and Winter, 1977, Nelson, 1980). To shift to a different existing technology with which they are not familiar would require the same kind of technical effort as developing a new technique of their own. It is characteristic of developed and developing countries, individual firms show considerable dispersion in their distance from the frontier. Any effort to move towards a 'given' frontier to achieve a major innovative breakthrough or minor adaptation is all variations on the same thing - conscious technological effort. Firms are not operating on anything resembling a neo-classical production function, with perfect knowledge of all techniques along that function between which they can costlessly shift as factor prices change, because in reality they pay a price for any technological change. No technology is applied in a completely 'given' form and changes are always necessary to suit local scales, materials, climate, skills and market needs (Lall, op.cit.).

By blending together the ideas and the conventional definition of leapfrog principle given above, we attempt to give a revised definition of leapfrogging to bring it in line with the situation in developing countries. Therefore, the leapfrog we are talking about in developing countries should be understood to mean skipping some technological development level and grow in capability and competitiveness - regardless of whether or not the enterprise is at world technological frontiers. The process is considered to be progressive, as learning implies, and the path is that of acquisition-assimilation-transformation starting from the mature technologies, first, and then go to consolidation and the fluid states. When the developing countries will have reached the stage of joining international competition at the fluid state, then, it means that they have graduated and catching up is done.

No doubt that information technology more than other technologies is the driving force behind the scientific and technological revolution that is taking place and the consequent rapid social and economic development in the world. It is helpful, therefore, the leapfrogging idea be given a special focus as the tool to scientific and technological and the consequent social and economic development. We think *rat Hobday's conclusion that no "leapfrogging" has taken place in the East Asian NIEs is due to semantic problem as he takes a narrow definition. He himself acknowledges that all the dragons have moved much more rapidly than European countries to develop their telecommunication infrastructure and related services and to expand their manufacture of a widening variety of electronic consumer and capital goods.

2.5 Policies in the models of technological change

It is possible to consider technological capability as the result of these fundamental components: the individual, the institutions and the common purpose (Enos, 1991). Individuals come with the skills. The institutions permit all individual technical skills and knowledge to be assembled and applied. While the common purpose acts as glue to keep together the individuals and the institutions to be able to pull in the same direction.

Everybody agrees about the higher skill requirement for technological development to occur. With regard to institutions, many authors have even gone as far as thinking of 'national innovative systems' as an important requisite for a country to catching up or even leapfrog technologically advanced countries. Common purpose at micro or macro level is taken as a fact but when it comes to national policies, opinions divide. Free market advocates don't want government interventions to disturb the market forces, which are considered to be by far more efficient than the government. On the other hand, there are advocates of state intervention because of market imperfections. The reality is that even in countries where free market is fully professed, governments are strong and they do intervene directly and indirectly in the development of their national economies. These government interventions are usually done through policy instruments. We have plenty of examples from the OECD countries of Science, technology, and innovation policies. It is now accepted that most East Asian governments intervened widely and in different ways in their markets but debate still continues on the nature and effects of these interventions and market failures affecting development.

Policies are instruments used by governments, corporations, and enterprises to direct their efforts towards desirable goals. In technology development and increasing industrial competitiveness, developing countries governments have tried different policies such as selective intervention by picking the 'national champions'. There is a talk of economically justifiable policies for technology development as market-stimulating technology policies (MSTPs) (Lall and Teubal, 1998). This framework is based upon evolutionary approaches to technology and goes beyond the current industrial policy debate of functional versus selective policies and proposes three sets of polices: functional, horizontal, and vertical. MSTPs may involve strong interventions in free markets for extended periods, and in some circumstances may involve doing without markets altogether. But policies do not always work the way their -designers expect them. This is because the elements affected by these policies react to it and the result may be positive or negative or mixed. The assumption that policy makers know what is best may be farfetched. But if the policy-making mechanism is part of the interacting elements and not a detached or far away from it, there is a possibility of constantly improving it in a dynamic environment where learning and feedback from the affected parties are the input for the next iteration. Mistakes are inevitable and the government has to have its own learning adjustment (Teubal, 1996).

In absence of explicit policies, with time, implicit policies may emerge as a tradition or a norm that the interacting elements take as a reference point. Some people call this as 'laissez-faire' policy. The assumption is that everybody is free to do what she/he thinks right or maximises his or her interests (benefits). These can be equated to the free market mechanism. Free market system does also fail. They tend to under-invest whenever the return from investment is not immediate. World Bank (1993) has advocated for market -friendly policies where governments are encouraged to follow neutral policies to make markets function better. Lall and Teubal (1998) criticise it for assuming, in the area of technology development, that there are no externalities in or missing markets for technological activity, no risky or prolonged learning sequences, no co-ordination problems between investments in different activities, and no externalities or collective learning phenomena. They argue that there is a role for both horizontal and targeted policies to promote the undertaking of technological activity and maximising their economic benefits.

Given this research is all about national S&T policy analysis and management, we have found the MSTP idea of Lall and Teubal (ibid.) very interesting. We will elaborate it further in the following paragraphs.

MSTP tries to achieve and it does include three major categories of policy:

1. Priorities (category 1): Setting national priorities for industrial and technological development in the broader context of economic and social objectives.
2. Incentives (category 2): Providing signals to economic agents for industrial or technological activity where markets fail to do so adequately.
3. Institutions (category 3); Generating non-market mechanisms, institutions and organisations including policy mechanisms, to underpin the previous two categories.

The first category or what are called priorities, deals with technology policy-making, strategic priority setting, involves general objectives of national and economic and industrial development and, within these, priorities are given to activities in innovation, technology and industrial development. National priorities set the parameters within which all other allocation decisions are made. These choices may be left implicit - for instance, leaving all choices to free markets (though this is not possible for several broad social and economic allocations decisions) is one way of assigning priorities - or they may be explicit, involving targets and plans. In the technology sphere, priority setting generally involves shifting the economy from a low to a high technology growth path: taking on more complex industrial activities, increasing the local content of production and design, increasing local innovative capabilities, and so on. In most cases, this involves identifying activities, or group of activities with significant technological potential that can generate beneficial externalities for other activities. Once activities and clusters are identified, the next task is to set technological priorities between competing uses, taking into account feedback and inter-linkages.

The second category (or incentives) involves the formulation and implementation of technology policies at the program level. These comprise the enhancement of technology infrastructure (functional level), the design of new programs to subsidise industrial training or research (horizontal level), and the promotion of enterprises to enter chosen technologically demanding areas by means of protection or targeted credit (vertical level) (ibid.).

Institution building or the third category does refer to generating appropriate policy mechanisms and capabilities for priority setting and implementation, and to setting up new institutions and organisations, in the public or private sector, to support, interact with and link up market agents. Examples in the public sector are technology institutions providing public goods such as basic research, extension services, standards and methodology. In the private sector fostering large conglomerates (as in Japan and Korea) to internalise deficient market for capital, skills, information and entrepreneurship, or setting up industry associations to undertake technological services for their members. Some of these institutions may concern the 'rules of the game' for technological and industrial activity such as competition policy, intellectual property protection or corporate governance provisions (ibid.).

The researcher, based on the approach of Enos (1991) and that of Lall and Teubal (1998), has taken policy-making (common purpose or priorities), human resource development (individuals), and institutional capability (incentives or institutions) as important variables in the process of technological development of developing countries. Competent governments are vitally significant for economic development in the developing countries. It is the most important explanatory variable (Reynolds, 1983). Therefore, the interactions among all types of organisations in a given economy are considered important, hence, it should be explicitly recognised in the research framework. After all, the networking and the work culture they create are usually country specific and may lead to the building of 'comparative advantage' of the country. This can also be linked to the concept of 'national innovative system' (Nelson, 1993). Continuous learning has been recognised in the framework. All of these are interlinked in an open system within the international environment. Now it is time to use the different theoretical analyses made above to build a framework for the purpose of this research.

2.6 The Research Framework

This research and the research framework, on which it is based, therefore, stand on the following major points:

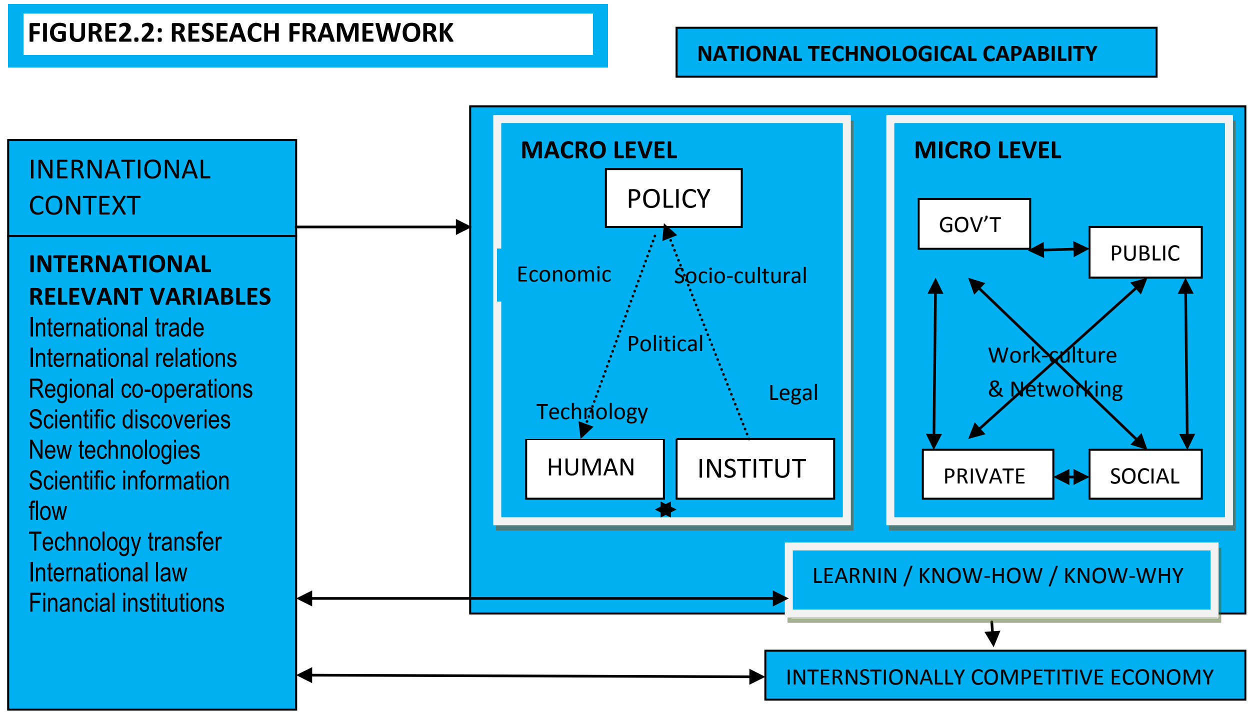
1. Science and technology and the consequent innovations are at the basis of internationally competitive economies and enterprises in today's world. Developing countries need to connect to the new global economy by trying to catching-up fast, or otherwise they will remain at the margin as they are today.

2. At a given historic time, some technologies are more important than others in terms of greatest impact on the whole economic and social development of a given country are. Today and in the coming decades, information technology is such a technology. Therefore, developing countries need to give it the due attention.
3. Developing countries are not a closed system rather they are an open system within the international dynamic environment. They have also their own internal dynamics. This is a threat and it is, at the same time, an opportunity. Learning to adapt to this continuously changing environment is a must. Therefore, the models of economic and social development they adopt should be based on a culture of continuous learning in order to exploit opportunities offered by this complex dynamic environment.
4. For catching-up, developing countries need to have clear vision, realistic long-term objectives, and adequate strategies to start with. To do this a determined and committed leadership is required. Of course, this leadership has to be also legitimate and free from corruption.
5. The tacit and explicit skills of its people need to grow to be up to the challenge.
6. Institutions are the melting pot where all the individual skills are mixed to create effective and highly productive teams, organisations, and industries that are networked to mutually complement each other and form a real 'national innovation system' to enable the country to gain some competitive advantage in the international markets.

Therefore, based on the literature discussed above we have made the following assumption:

A developing country can leapfrog by using the reverse process of acquisition-assimilation improvement (generation) of technologies to create internationally competitive economies though an integrated approach where macroeconomics policies, S&T policies, human capital and institutions work in line in a dynamic process of continuous learning' IT is pervasive and. as such is the technology of priority, which can increase the knowledge generation of developing countries and connect them to the global economy and reduce the technological gap.

FIGURE2.2: RESEACH FRAMEWORK



To be able to take the above assumption as a point of departure of our study, an attempt has been made to develop a suitable framework. This framework wants to capture the basic factors that determine the development of the technological capability of a country and it is going to be used in this case study of Eritrea. The diagnosis made at the three levels is based on the framework given below in Figure 2.2. First of all, technological capability of a given country depends on a number of variables. These are the economic and social policies (objectives and priorities) of the country, the science and technology policies at the macro level (country or region within the country) and policies and implementation management at the micro-level (industry and firm level) which are based on the macro level' Second, it depends on the institutional capability it has been able to develop. Third, the quality of its human resources should be capable to support the desired change.

When we talk of 'policies' we refer to the sense of purpose and long-term objectives, and the strategies employed to achieve them. The ability of having a sense of direction and consistent long-term objectives in turn depends very much on the quality of human resources (the quality of leadership, their skill and experience, and their ethical standard, and the skill of its work force). Of course, institutional capability is very crucial to sustain the sense of purpose and highly skilled manpower development. The three of them need each other to be complete. But these things depend in turn on the political, legal, economic, technological, and social environment that exists in the country. We can have different approaches within a continuum from a free market to planned economy system, which each country develops based on its past and present socio-political systems. This stage in the framework has been labelled as 'Macro-level' because we are looking at it from the country level.

Second, what we could not see at the macro-level but nonetheless are very determinant elements in the development of technological capabilities such as the different government institutions/departments, public enterprises, private enterprises, and other social institutions are explicitly recognised by this framework in their dynamic interaction. This is not all; the dark background in which these elements interact creates a network which will determine the particular work and business culture of that country. Of course, the bigger the country we could have more of such networks at district, or state level. It is these unique industrial networks and business cultures that create the 'comparative advantage' of countries and increase their international competitiveness. It is this network that enables the diffusion of new technologies and the best business practice. But this network and linkage should by no means be limited to the country, it should go beyond it. It should become part of the international network. In fact, the sophistication and ability of a given country to be linked to international science and technology network, to the international marketing networks, and to international financial networks can give us indications on how matured is that country's economic development. This is also at the basis of the institutional capability development as given by North (1990).

Third what we have seen so far both at the macro-level and micro-level is not a closed system but it does interact with the rest of the world. It takes from and gives back to the international community. This taking and giving will take place within the context of the international relations, international trade, regional scientific and technological as well as economic co-operations, regional markets, the extent of globalisation, and legal system that exist. It can benefit from the poof of science and technology available in the world through different technology transfer mechanisms.

Fourth, no country was born with scientific and technological maturity. Each country had to learn it. The less developed countries acquire science and technology in different form from the advanced ones. Usually they learn, first, how to acquire new technology (or science) and slowly assimilate it and adapt it to their own needs; and finally start to innovate and invent. Learning occurs at every stage and it is continuous. Therefore, the framework proposed explicitly recognises learning as an important variable in the process of development.

Finally, if the country has properly mastered the know-how, first, and the know-why, later, as the basis for its innovations, it means it has reached the stage where it will have developed an internationally competitive economy in every sense. It means that it is getting a fair share of the international wealth and its people can enjoy a decent living standard. At the same time, the country will start contributing in science and technology development of the international community. And all re-starts again.

This framework is based on some important assumptions as well. When it says 'Science & Technology' it is always assuming that at the heart of it is information technology as a pervasive and enabling technology. Every time that it uses the word 'policy' it wants to mean the clear sense of purpose and how to achieve it whether it is at country level or at organisational level.

Another assumption is the dynamic nature of the framework. The policies of a country must always be revised to keep into account the changing international and local environments. The human resource planning and development should reflect that dynamic character by trying to recognise the changing skill needs and train people accordingly. The type of institution in place has to restructure to give all the necessary support for the right scientific and technological development and diffusion for industrial innovations. This should be repeated at the micro-level as well.

Some people may be tempted to see in the above framework a top-down approach to technological capability development with the government determining everything. Our assumption with this regard, therefore, must be made clear from the outset. We think that the role of governments, whether in less developed countries or developed countries, has been always important regardless of whether the country is a planned economy or a free market economy. But given the immature market systems that we have in less developed economies, the role of governments as active economic agents, beside that of regulators, is more pronounced. Therefore, our assumption is that all the active players in the economy determine the S&T policies of a country, even when we speak of national policies and plans. The government plays the role of a leader and co-ordinator of the economic agents and creates the right environment for development of technological capability.

In the case of Eritrea, the government has made it clear that Eritrea will be an "open, private sector led, free market economy". The role of the public sector being limited to "normal regulatory roles". But "at the same time, in view of the present dearth of a capable entrepreneurial business community in Eritre4 there is a clear need for a pioneering and catalytic role to be played by the government. However, in such cases, the terms of government participation will be on a strictly competitive basis and will be guided by principles of the market. The overall impact on the economy should be the encouragement of competition in the market and the stimulation of private investment activity. Thus public sector participation in productive economic activities should be seen in this light. The ultimate objective of the government is to withdraw completely from such areas and leave them to the private sector" (Macro-Policy, 1994: l5).

2.7 Conclusion

This research, following the line of thinking exposed above, would like to study the best way of developing the national system of innovation for a quick transformation of the Eritrean economy and society. It wants to focus particularly on information technology as an enabling infrastructure to become truly networked society with time and get connected to the new global economy. Of course, this is only possible in a 30-40 year time frame. But the question now is whether the experience in the advanced countries and the NIEs can be replicated in the least developed countries like Eritrea.

The power of information, communications and transport technologies has reduced the world into a big village where the different cultures are blending together. Differences in the way economies and trade are conducted, the way we run governments, the way we organise the education system etc. are ever shrinking and similarities are increasing. Even historical evidences can show us that scientific and technological development was not monopolised by a particular ethnic group or geographical region. Therefore, we can safely conclude that people learn new ways of doing things, in any society and culture, if they see the benefit. By the same token, the weakly structured, organised and managed national system of innovation in the developing countries can learn and change with capable hands and committed minds. A very good example of these is the spectacular development and the catching up made by the Four Tigers of Southeast Asia of Singapore, Hong Kong, Taiwan and Korea in the second half of the 20'n century.

If given the necessary skills, tools and properly organised and motivated, there is no reason why developing countries don't become productive and competitive like the rest. If the experience of the Southeast Asian Tigers is considered as exception, Eritrea is determined to be among these exceptions, but why be pessimistic? This should be the norm and every developing country should be able in catching up.

3

3. Research Methodology

3.1 introduction

This research is based on secondary and primary data. The secondary data search consisted of literature review on Science and technology policy, technology management, technology transfer, information technology, economics and technological change, and innovation systems.

The first task was to understand the state of technology policy and management in developing countries, in particular the Sub-Saharan countries of Africa. A lot has been said and done with regard to the economic development of African countries. What has been achieved is very negligible. To be exact many African countries are poorer than they were at the time of independence thirty-forty years ago. Some are virtually economically bankrupt with enormous foreign debt. Where has the euphoria of the time of independence gone? Western technology seemed to promise everything. What went wrong? What can technology do now for the Africans? These are all legitimate questions. We need to understand the past to be better prepared for the future.

Eritrea is a new country. It got its independence in 1993. It has to learn from the success and mistakes of other developing countries. It is from this perspective that this literature review is done. Role of governments in the industrial technology development must be properly understood, the role of the private sector, the role of donor countries, the role of industrial networks, and the role of government-universities-industry relationships.

Technology transfer literature search is the second task. It is very important to understand the different technology transfer methods to properly exploit them. The most cost effective and more sustainable technology transfer methods should be chosen and that is why a search of literature to learn from the experience of others becomes crucial at this stage. It is possible to learn from the technology transfer between companies as well as technology transfer between North-South, and technology transfer between South-South.

The third task is to understand the role of information technology in the economic development of a developing country like Eritrea. An attempt has been made to see if the model of other countries can be used in the case of Eritrea. For example, Singapore has been used as a model in a number of ways without leaving aside the successful experience of other developing countries as well. It is well understood that any model chosen, unless internalised and made one's own, cannot succeed. This means that Eritrea should develop the capability of learning from others and adapting things to its own situation. This introduces at this point the concept of whether a given social and cultural profile of a given country is suited or not to such successful learning. But based on past Eritrean experience it is safe to make the assumption that Eritrea has a track record of fast learning. One clear example is the reconstruction of national road networks and the resurrection of the railroad (which was built by the Italians and completely destroyed during the war of liberation) all being done by Eritreans that is taking place now.

The field research was looking into science and technology policies and management of Eritrea. The current diffusion of information technology in the country has been assessed. The following sections elaborate on this. Based on the above understandings and the objective realities of Eritrea, we will attempt to develop an alternative way to the appropriate development of the national innovation system of Eritrea. The development of IT will be given a particular attention as a very pervasive technology of today.

3.2 The research problem in perspective

This research is about information technology policy and management of Eritrea. It focuses on the civil services and the service industry, since the macro Policy of Eritrea puts service industry in a central place. When we say service industry we are referring to financial sector, trade, transport and communications, and tourism. This research has departed from the assumption that the major players in the financial sector in particular the Bank of Eritrea (BE), the Commercial Bank of Eritrea (CBE), and the National insurance Corporation of Eritrea (NICE) can play a leading role in the use and diffusion of information technology. But later on, during the field research, it became clear that even the financial sector was only at the initial stage in the use of information technology. Therefore, an adjustment on the original thinking was made. Without leaving the three cases from the financial sector, the researcher has included other cases from civil services and twelve of the major computer business firms.

At the same time it studied the state of S&T in Eritrea in general so that to put information technology in its appropriate context. Therefore, besides the case studies mentioned above, the research did conduct in-depth interviews with higher government officials to understand on how the implicit and explicit policies with regard to S&T, in general, and information technology in particular are made and implemented. This has been supplemented by a survey on the implementation of policies and diffusion of information technology in the country.

The focus has been on a particular variable of the economic development paradigm: -technology. It is the thesis of this research that information technology can play a very significant role in the economic development of Eritrea. Information technology is a pervasive technology in the sense that it is not particular to any industrial sector and it is completely reshaping the face of the service industry and it will continue to do so in the foreseeable future. Therefore, Eritrea has a good opportunity to leapfrogging by quickly mastering the use of information technology in its service industry in the whole process of its economic development. In other words, Eritrea to develop a good financial sector base of international standard should invest obviously in information technology. This can be the spin-off of the whole service industry of the country and definitely have a spill over effect to the other industries as well.

As we have already seen at the beginning, the main question of this research is how Eritrea can transfer science and technology, particularly information technology, for a successful transformation of its economy and its society and avoid the marginalisation threat from the new global economy. This main question has been divided into two sub-questions:

1. What is the state of science and technology policy in developing countries and, in particular, how are the developing countries managing their information technologies to avoid future costly dependencies?
2. How can Eritrea exploit the opportunities offered by information technologies to strengthen its economy based on the experiences of other developing countries?

It is very clear that the research is deliberately focusing on 'information technology'. This may be interpreted by some readers as if the research is taking from the outset that information technology is cure for all economic ills of the country. Not at all! It wants only to be a study from the perspective of technology. But no matter how important it is 'technology' is only one of the many variables that determine the economic performance of a given country. But lately, science and technology have become a 'sine qua non' in every sector of human life and development. Particularly the micro-electronic revolution is an enabling technology as well.

3.3 The case study design

This case study is of the type known as 'single-case-embedded' design (Yin, 1994, p.38-45). This is because it is based on multiple units of analysis. It is single-case because it deals with the information technology and economic development of Eritrea, which could also be generalised to other developing countries like Eritrea as well. It is embedded with multiple units of analysis because it takes various organisations from the banking and insurance sector, and other sectors of Eritrea to make a detailed study which will serve to give deeper insight into the subject matter. Therefore, the multiple units of analysis used are information technology in Eritrea, as the main unit of analysis; and the sub-units are II in the financial sector, in agricultural sector, in the industrial sector, in trade and services sector, and in the civil services. Besides, the very nature of IT is pervasive to all industries. Lessons learned in one industry can be easily transferred to the others. Furthermore, IT in the financial sector in particular has become a 'sine qua non' competitive weapon.

In-depth interviews were made with higher government officials on how the science and technology policies and IT policies are made and implemented. Finally, the understanding of IT use and diffusion in the administration of the civil services and public and private enterprises will enable us to have a reasonably comprehensive view of how the country is doing in IT. Based on this knowledge and the experiences of the other developing countries we have explored in the first part of the research we would be in a position to say how best Eritrea can exploit IT in the future. Lastly, the case study strategy has been selected because every country is a unique subject of study.

Five components of a research design are especially important: (l) a study's questions, (2) its propositions, if any, (3) its unit(s) of analysis, (4) the logic linking the data to the propositions, and, (5) the criteria for interpreting the findings (Yin, 1994). This case study is based on the five components.

3.3.1 Study questions

This case study wants to answer the following two basic questions:

1. What is the state of S&T policy and management in developing countries including Eritrea? What is the state of IT in these countries?
2. How can Eritrea exploit best the opportunities offered by IT for its economic and social development based on the experience of other developing countries (in particular that of NIEs)?

These study questions are of the form of 'what', 'How' and 'Why'. All types of questions that require explanations of present situations in Eritrea and how to bring change in the future. Therefore, the case study strategy is considered viable. But when you go into the first two questions at some point of the study it becomes necessary to ask also detailed questions such as: what, who, where, and how many. This means that the case study needs to be supplemented by a survey study, which is conducted for IT diffusion in Eritrea.

3.3.2 Study objectives

The objectives of this research are the following:

1. To understand the difficulties encountered by developing countries in the process of economic development in limiting their technological dependence.

2. To develop a model of an effective Science & technology base development for Eritrea based on the above understanding.
3. To develop a plan for sustainable information technology base for Eritrea.

The thesis of this research is the following:

Eritrea can exploit the leapfrogging principle using the information technology in the development of its economy, in particular the trade and service industry. The development of a good financial sector of international standard which is based and led by information technology can act as the spin-off of the whole service industry of the country and will have a spill-over effect to the other industries as well leading to a healthy economic development.

3.3.3 Unit of Analysis

The unit of analysis of this case study is the use of information technology for Eritrean economic development. All the literature review about Science and technology management & policy in developing countries are the context of case study. While the state of science and - technology management & policy of Eritrea, the present state of information technology development in Eritrean economy are all the immediate topics of the case study. In other words 'information technology in Eritrea' is the central unit of analysis while the different sector studies are sub-units of analysis. They are not the ends in themselves but only the means to the central question of this study.

3.3.4 Linking Data to Propositions

In the study of the success and failure of developing countries in their struggle of economic emancipation, we would be talking about their experience as the testing ground of the different technology economic growth theories and models of economic development. This is very important to this case study because this new country need not re-invent the wheel. But since there are too many theories and models a careful study is required to select the right model that matches the economic context of the country. Therefore, this part of the study is considered very relevant to bypass.

From the financial sector, the study of BE, CBE, and NICE in terms of information technology infrastructure, managerial capability, skilled manpower availability, and the information technology strategies and their implementation was expected to be revealing about the situation of Eritrea as a whole which was not the case. As a result, during the fieldwork, a change has been made to capture information technology transfer and development in all sectors where some learning was taking place. But the in-depth study of the three financial institutions may lead to concrete suggestions of possible future plans of how to best transfer and use information technology to create internationally competitive financial sector. Based on all fieldwork study some policy suggestions have been derived for the policy makers. In short the data collected are relevant for the research to achieve its objectives. At the end, this study does have policy implications to other developing countries as well.

3.3.5 Criteria for interpreting the findings

Any finding of the case study is interpreted against the framework we have developed based on the literature research on information technology and economic growth, in general, and the experience of the most successful developing countries. Therefore, in line with the research framework developed in chapter 2, the criteria for interpreting the findings were based on the following major criteria:

l. Policy issues: Each explicit or implicit policy decision on S&T issues in Eritrea were examined against (l) 'consistency', Q 'adaptability', and (3) 'implimentability'. 'Consistency' refers to whether the policy is consistent with the long-term socio-economic development objectives of the country. Whether it is consistent with the 'export-oriented open and free market led by the private sector', or whether it is consistent with the country specific social and cultural environment, or whether it is consistent with existing policies. When we say 'adaptability' we refer to the possibilities of policy to evolve and change in response to changes in domestic and international factors. When we say 'implementability' we are looking on whether it is easy to put the policy into action given the resources available to the country at a given time.

2. Human resource issues: One of the cornerstones of technological capability development is skilled manpower. The Eritrean skilled manpower resources has been assessed against the demand that each policy on S&T does make, compare it with the existing educational system capacity to supply those skills, and determine the gap that exists between demand and supply. At the end recommend on how to fill the gap. Criteria of assessment used were the number and experience of skilled professionals and scientists in the country.

3. Institutional issues: Developing industrial technological capability requires a lot of institutional support. To what extent the institutional capability is developed in Eritrea is determined from the field research and assessed the institutional gap critical for the industrial technology development. That is, educational and training institutions, research institutes, universities, funding institutions, and the private sector and their interrelationships and co-operation was assessed to find a solution to fill the possible gaps. The major criterion on which institutional capability was assessed is the degree of trust and co-operation among government and private institutions and the industrial networking that is emerging in the country.

4. Science and technology diffusion: But given the country wants to catch up, the strategic importance of S&T in general and information technology in particular for service sector is very central in the future of economic development of Eritrea. Therefore, the following criteria for evaluating S&T and IT development in Eritrea will be used: sustainability, flexibility & transferability, quality, priority and result or international competitiveness. The technology chosen for transfer should be sustainable in terms of financial investment at the beginning or during its operational lifetime, in terms of local skills to operate and maintain it, and in terms of upgrading and improving it in the future. In a world where change is continuous and innovations continue without stop flexibility to adapt to new changes and the transfer of skills and knowledge from one sector to another as well as from the first generation of technology to the next becomes necessary. A good management of technology needs to consider it and we will take it as another way of measuring the performance of S&T development. Demanding customers want quality of goods and services and to satisfy it quality standards in the industry need be high. This comes only if a culture of quality has been nurtured. We will take it as other evaluative criteria. Technologies are not equally important. Given the particular circumstances of the country some technologies are more important than others are. We feel that IT as a pervasive technology is very important and as such need be given priority for the multiple uses it has. Finally, the expected result from S&T investment is higher socio-economic development, which we will try to measure by the degree of international competitiveness achieved.

3.4 Field Research

The researcher himself did all the in-depth interviews, which were mainly unstructured interviews (Appendix I0). While the survey was done with the help of research assistants which was mainly structured interviews (Appendix 9).

A careful preparation has been made for the unstructured interviews. A checklist of questions for each variable that is central to the research was prepared in order to make sure that only -the relevant questions are asked. Of course the researcher was flexible and adaptive during the course of the interview to allow the natural flow of events. If an analogy is possible here, it is like in mining. You dig deeper and deeper by following the track of the precious metal you are looking for. You cannot follow a pre-determined course regardless of the clues and evidence you get as you dig. This means also that you don't allow preconceived notions to dictate your research. The confidence of being able to flexibly move can only come from a deep understanding of the subject matter being studied. This is another important reason why the researcher did make a thorough literature review on the subject matter. Lastly, to be able to follow the track properly, the researcher's mind should constantly be on what the interviewee is trying to say, possibly, take it with the whole context in which it is being said. This means the spirit of observation is a great asset. The researcher has no the illusion that he has mastered all these skills but he did his best to use the field research as a training arena.

About forty in-depth interviews have been conducted with government officials at ministerial level that have to do with science and technology management and policy issues, with the BE, CBE, and NICE executives, and managers from the private enterprises.

The survey was made of a sample of 2M organisations taken from the civil services, international organisations and private enterprises, It was meant to capture the extent and pattern of information technology diffusion in the country, They consisted of 62 government organisations, 22 public enterprises, 113 from the private enterprises, and 7 international organisations. This sample was taken from a population of 'organisations most likely to have computers'. Based on the in-depth interview and the observation made, the civil services was one of the biggest users of computers in the country, every effort has been made to include all the government departments and agencies. All public enterprises have been included because they are among the large enterprises. From the private sector, all the large enterprises, all computer service businesses, a random sample from the travel agencies, a random sample from consulting firms, three each from photographic services, hotels, and private clinics and laboratories, the big five from printing press, and almost all the international organisations.

In this case study all possible sources of evidence were used. Besides the interviews, direct observation, documents, records, and open-ended interviews with key informants was used. Each in-depth interview was written immediately after interview and passed to the interviewee to check for accuracy. A report of the personal observations of the cases with regard to computer hardware and software has been made. Besides, copies of documents and records where ever possible were made for the case study database.

Data were collected pertaining science and technology policy and management, information technology policy and management, skilled manpower availability, information technology professionals training, information technology networks, information technology in the financial sector, and investments in information technology infrastructure development. Data collected in Eritrea was analysed using the framework that we have discussed earlier.

The analysis did identify the critical variables for Eritrean information technology base development and it spells out what resources are required and how possibly to get them and how to implement it in the shortest possible time frame.

All the analysis was guided by the following criteria: simplicity, relevancy and accuracy. In other words, the general model considered, by studying Singapore, was adapted to the specific socio-economic situation of Eritrea. A simple adapted model that could be relevant and at the same time with all the necessary elements to make it an accurate representation of the technological development for economic growth in Eritrea.

3.5 Conclusion

The field research was planned to focus particularly on the financial institutions. But when it became evident to the researcher that information technology use in the three case studies (BE, CBE, and NICE) were at the initial stage, the research plan had to be reassessed and changed to accommodate the reality of the country. The logic of focusing on the financial institutions was that they are bigger relative to the rest of enterprises in the country and that they have the money to invest in information technology. Besides, the trends in international financial institutions is that of heavy informatisation and digitisation of information and services, therefore, that was expected to pressurise the Eritrean financial institutions to follow suit for the very reason of getting connected to the rest of the world. Therefore, the change made was to look for enterprises of organisations with significant experience in information technology use to see if anything can be learned from their experience as well.

It is very important to make few remarks on the limitations of this research. The biggest limitation is the fact that SSA countries are the least researched countries particularly with regard to S&T. In the literature, there are only scanty country-based S&T studies.

Information technology, as a very recent phenomenon in Africa, is again worse. Therefore, whatever has been said should be taken with this poverty of information prevalent on SSA countries in mind. The other limiting factor is the breadth of the study itself. The research from the outset has made a deliberate choice of studying the subject from broader perspective father than from narrow perspective that focuses on few variables. An attempt has been made to capture the complex reality of S&T in relation to innovation to benefit a given national economy. The insight gained from breadth point of view has been made at the expense of in-depth treatment of the subject matter. But the trade-off has been made because the aim was to give as complete picture as possible to assist policy makers to understand the complexity of the subject at hand. It is hoped the balance between what is desirable from the academic point of view and that of the practitioners and policy decision-makers has been achieved.

PART I
S&T in Newly Industrialised Economies

A glimmer of hope for the developing countries has come from the newly industrialised countries. Catching –up is a possibility.

Part I will enable us to deal with our first study question: What is the state of S&T policy and management in developing country? What is the state of IT in these countries? Since we have classified the developing countries into three parts: NIEs, SSA countries, and Eritrea, this part will deal with the first group of countries.

These countries have had a significant success in their socio-economic development in the last four decades. Eritrea as a new country does have a limited past experience on science and technology policies and management, IT can learn from other developing countries, in this case from the NIEs in Asia and Latin America, because in these countries many different policies have been tried with different degree of success and sometimes failure as well. There is a vast literature that analyses the reasons of success and failure. Even though sometimes the researchers themselves do not agree, these studies give us valuable insights. At the end of the day a country learns by doing.

The assumption is that all developing countries, wherever they are, have similar problems like shortage of skilled manpower, lack of institutional capability, lack of infrastructure for science and technology development, lack of necessary capital, etc. Based on these similarities we think that Africa can find a lot to learn from the experience of NIEs in Asia and Latin American. Notwithstanding the socio-political differences that exist among them, it is possible to identify the common major factors that have helped or hindered the scientific and technological development in these countries. But we are not assuming that projects that have succeeded elsewhere can be directly applied in Africa. Even today in times of increased globalisation, countries have their unique characteristics that need always be taken into consideration in policy analysis of this nature. But there is always possibility of learning from one another without losing one's identity. For example, the Japanese are cited as a good case in their ability to acquire their technologies from the West and retain at the same time their cultural identity. What they did was to learn the technology and effectively use it within the framework of their own cultural context. By the same token, African countries, in this case Eritrea can learn from the experience of the successful Asian and Latin American countries. The learning that we think is readily transferable is those technical, organisational and the dynamics of technological development itself.

The sections and sub-sections are organised following the framework presented in chapter two: the environmental context, science and technology policy and management, institutional capacity development, human resource development, the 'melting pot' where we discuss the link of S&T to economic development, and lessons learned as concluding remarks. The same pattern will be maintained also in the following parts of this research.

4

4. S&T in Newly Industrialised Economies

4.1 introduction

In this chapter we do discuss about the experience of the NIEs of South and East Asia and Latin America, specifically of Singapore, South Korea, Taiwan, Hong Kong, Brazil and India. Why have these countries been selected? This is a judgement sampling. The four tigers of Southeast Asia are included because they are the ones that have made a successful and fast economic and technological change in the last four decades. Only in the beginning of the 1960s they had all the typical traits of least developed economies. Their rapid development has been possible through industrialisation. They are like the laboratory for what we are looking for. Brazil, in its own way, has a similar rich experience, even though less successful than the Southeast Asian countries. India, on the other hand, has both the traits of least developing and industrialising countries. Some authors do not include it among the NIEs. But it has been able to develop an impressive broad-ranged scientific and technological capacity, which makes it a country with latent capacity and a great potential of fast economic growth and development. In fact, India is a good case to look into for it has failed to exploit its scientific and technological achievements for economic development, as the counterpart countries of Southeast Asia did.

Table 4.1: Growth of the of NIEs

Country	Population Millions 1997	GNP Billions 1997	Rank	GNP/per Capita 1997	Rank	Growth of the economy: Annual % growth Value added for 1980-0 and 1990-97										Gross domestic Investments 1990-97
						GDP		Agriculture		Industry		Services		Exports		
Brazil	164	773.4	8	4,720	34	2.8	3.1	2.8	3.9	2.0	2.5	3.6	3.7	7.5	6.0	4.0
Hong Kong	7	164.4	26	25,280	13	6.9	5.3	-	-	-	-	-	-	14.4	11.1	11.1
India	961	373.9	15	390	102	5.8	5.9	3.1	3.0	7.1	7.1	6.7	7.5	5.9	13.7	8.9
S. Korea	46	485.2	11	10,550	25	9.5	7.2	2.8	2.1	12.1	7.5	9.0	7.8	12.0	15.7	6.3
Singapore	3	101.8	34	32,940	4	6.6	8.5	-6.2	1.8	5.4	9.1	7.5	8.4	10.8	13.3	9.8
Taiwan*	20	n.a		17,720		8.3		n.a		n.a		n.a		n.a		n.a

Source: World Bank, World Development Report, 1998/99 *Economist March 7, 1998 (per capita at purchasing power parity and GDP growth is the avenge of 1970-96)

In the last four decades these countries, each in its own way, tried to make a remarkable technological catching up. Economically, the least successful of the group has been India. Brazil had its own successes during the 60s and 70s but it was not sustainable because of the huge debt burden, which was exposed during the oil shocks of the 70s. The other four Tigers were all a success story till the recent Asian financial crisis of 199617. During the 1980-1997 period, Brazil managed to keep an economic growth around the 3% per year, India slightly below 6%, while Korea, Taiwan and Singapore grew at 7 or more percent with Hong Kong slightly below the other three at around 6.5% (see table 4.1). During the 1980s, export in Brazil grew by 7.5% per year, in India 5.9%, Hong Kong 14.4%, Korea 12%, Singapore 10.8% and data for Taiwan was not available. While during the 1990-97 period, the export growth of Brazil and Hong Kong declined by 6% and 11.1% per annum respectively, that of India, Korea, and Singapore increased to 13.7%, 15.7%, and

13.3% per annum respectively. The export growth shown particularly by the four tigers was a sign of greater international competitiveness.

Table 4.2: S&T development indicators of NIEs

Country	Public expenditure Edu. % GNP		Net enrolment ratio % of relevant age group				Scientists and engineers in R&D/Millions	High Technology exports % of mfg export 1996	Number of patents filed field 1995	
			Primary		Secondary				Residents	Non-residents
	1980	1995	1980	1995	1980	1995	1981-1995			
Brazil	3.6	-	80	90	14	19	165	18	2,757	23,040
Hong Kong	-	2.8	95	91	61	71	-	27	23	1,938
India	2.8	3.5	-	-	-	-	151	10	1,545	5,021
S. Korea	3.7	3.7	100	99	70	96	2,636	39	59,249	37,308
Singapore	2.8	3.0	99	-	-	-	2,512	71	10	11,871
Taiwan	n.a		n.a		n.a		n.a	n.a	n.a	n.a

Source: World Bank, World Development Report, 1998/99

If we study the high technology exports, we see that Singapore and Korea stands out of the group. The high technology exports as a per cent of manufacturing exports in 1996 was 71% for Singapore, followed by 39% for Korea, Hong Kong 27%, Brazil 18% and the least India 10%. Both Singapore and Korea have the highest number of scientists and engineers in R&D 2,512 and 2,636 pet million respectively. But when we look at the number of patent applications filed, Korea alone seems to have the upper hand with 96,557 of which 6l.4% are patents filed by residents. Singapore has a total of 11,881 almost all by non-residents. Brazil has 25,797 with 10.7% by residents while India has 6,566 with 23.5% by residents. It is clear that the Korean economy is highly indigenised while that of Singapore is dominated by the Multinationals. Foreign companies also seem to have dominated Brazil's patents.

Public expenditure on education as percent of GNP in all the countries in our sample is similar, which is around the 3 percent. The highest spender is South Korea at 3.7 percent, which seems to be kept at that high level for quite a long time. The net enrolment ratio as percent of relevant age group at the primary level is high in all the countries except India. At the secondary level Brazil and India do not match the Southeast Asian countries. There is a huge gap. For example, Brazil has 19 percent secondary enrolment ratio while that of Southeast Asian countries is above 70 percent. Many writers have attributed the high enrolment ratios at primary and secondary levels of the Southeast Asian countries to the Confucian culture.

Table 4.3: Structure of the economy of NIEs

Country	Structure of output of economy: Value added as of GDP							
	Agriculture		Industry		Manufacturing		Services	
	1980	1997	1980	1997	1980	1997	1980	1997
Brazil	11	14	44	36	33	23	45	50
Hong Kong	1	0	32	15	24	7	67	84
India	38	27	26	30	18	19	36	43
S. Korea	15	6	40	43	28	26	45	51
Singapore	1	6	38	36	29	26	61	64
Taiwan								

Source: World Bank, World Development Report 1998/99.

The structure of these economies (table 4.3) shows that in 1997 India's agriculture and industry contribution to GDP was 57% almost in equal proportion while that of Brazil 50% and Korea 49%, the contribution of agriculture being 14% for Brazil and only 6% for Korea. Hong Kong and Singapore had totally different structure. These two economies depend only on industry and services, particularly that of services. In 1997 Hong Kong and Singapore had 84% and 64% of service contribution to their GDP respectively while the difference coming from industry. The economic structure of Korea seems to have more similarity to that of advanced countries while that of Brazil and India is less so, particularly that of India is typical developing economy structure. The structure of Singapore and Hong Kong is typically that of a post-industrial society, may be the result of them being city-states.

These six countries' production of electronic data processing and office equipment as a percentage of the world production grew from 4.7% in 1985 to li.lvo in 1992 (see table 4.4). It was three times more than a decade earlier, and of these 15.1%. Only Singapore and Taiwan contributed 61%... In 1985 Singapore, Brazil and Taiwan were contributing about the same amount while Korea and Hong Kong were contributing only about half of that. India was contributing only one 10th of Taiwan. In 1992, Korea and India grew almost by the average growth of the six (growth of 3.2 times that of 1985), Brazil and Hong Kong grew below average 2.18 and 1.86 times respectively, while Singapore and Taiwan grew above average by 4.33 and 4.0 times respectively.

Table 4.4: NIEs production of electronic data processing and office equipment (percentage)

Country	Year			
	1985	1988	1991	1992
Brazil	1.1	1.7	2.6	2.4
Hong Kong	0.7	0.9	1.2	1.3
India	0.1	0.3	0.3	0.3
S. Korea	0.6	1.5	1.9	1.9
Singapore	1.2	2.7	4.1	5.2
Taiwan	1.0	2.7	3.1	4.0
OECD-18	94.8	89.6	85.	82.3
S. Africa	0.0	0.1	0.1	0.1

Source: OECD (1995)

The point is that the NIEs have succeeded to catch up the advanced countries in many respects, particularly the four tigers of Southeast Asia. This ability to succeed in the global markets is a sign of greater innovativeness, which is the direct result from the ability to reverse the industrialisation process of acquisition-assimilation-generation of new technologies. It is not difficult to notice that countries like Korea that heavily invested in science and technology are the ones that have succeeded to reduce foreign technology dependency.

In the coming two chapters, we will argue that NIEs have been able to break the vicious circle in which developing countries are usually found by investing more in science and technology through human capital formation and institutional capacity development all integrated within their socio-economic development plans. We will argue that the less successful, on the contrary, have neglected the balanced growth of the human capital - formation and institutional capacities to support their socio-economic development.

4.2 Environmental context

Until around forty years ago, the developing countries had almost no industrial capacity. The severe deficiencies in their social and physical infrastructure made building such capacity difficult, and their lack of experience in economic management exacerbated their problem. In the manufacturing sector, they lacked capital, technical skills, and, above all, entrepreneurial and managerial capacity. Yet in the span of a generation, some of the developing countries have built up a fully industrialised structure (Hughes, 1980).

Hughes was correct to point out that it was widely believed until the 1960s that developing countries would not be able to compete in international markets. But from 1960 to 1975 such export grew at about I5% a year compared with a record 10% a year growth for manufactured exports from industrialised countries, The most rapidly growing developing countries have been those that, without neglecting other sectors, have achieved the most efficient and rapid growth in manufacturing industries, These are the countries in Southeast Asia like Singapore, Hong Kong, Taiwan and South Korea.

Industrialisation has been the key to catching up to the high living standards and political stature of industrialised countries. The development of a manufacturing sector has been seen to depend on access to modern technology, with its concomitant high productivity. It was argued that spill over effects on the rest of the economy would result from the production to sophisticated intermediate inputs and capital goods. Industrialisation has thus been seen as an instrument that would also transform agriculture, construction, transport, and other service industries into highly productive sectors. A strategy of promoting industrialisation by protecting infant industries was considered inevitable by all developing countries because of trade barriers in the international trade and the imperfect internal market structure of the developing countries themselves. Hong Kong and Singapore are considered an exception to the rule for being less interventionist and protectionist. But Singapore is well known for its different type of government intervention of the so-called 'entrepreneurial-state' type, which we will discuss later on.

It is also interesting to note the difference in approach. Hughes (ibid.) calls "basic industries" approach the one followed by some countries, in particular India that sought to industrialise around an indigenous core of such industries as heavy metals, chemicals, and capital goods. This strategy tended to be very costly in its use of capital as a result of long periods of gestation. The other is 'consumption industries' approach which is followed by more market oriented countries like the four Southeast Asian Tigers. These industries focused on mainly assembly of imported materials and gradually worked backward toward basic industries. The trick was to progressively accumulate the capital required for the development of the latter so the industrialisation tended to demand less capital than in the first approach. Some industries such as textiles, footwear, furniture, domestic utensils, building materials, and food processing were common to both strategies.

It is very important to understand the context in which developing countries were working to emancipate themselves politically and economically. With the exception of Brazil, which gained its independence from Portugd in 1822, all the other NIEs and India got their independence after the World War II. The anti colonial sentiments were fresh. Development economics was getting inspiration from the socialist movements because of a concern with poverty and the bias against the capitalist system of labour exploitation and, thus, alleviation of poverty has been a central theme of industrialisation from the 1940s. Major aid donors in the West and their market-oriented economists severely criticised, for more than a decade, countries attempting to introduce socially oriented development policies. They were so preoccupied with growth that they tended to neglect its underlying objectives, i.e. alleviation of poverty and just income redistribution. It is somewhat ironic to find developing countries under attack, now, for ignoring social objectives. This is without doubt the effect of 'cold war' where the two camps, capitalist and socialist, were fighting for zones of influence. Of course, industrialisation and alleviation of poverty are complementary. But government taxation and investment policies should be appropriate, and should provide the choice of techniques that take account of availability of capital and labour for industrial development can have a direct impact on employment and standards of living even in the short run (Hughes, ibid.).

The idea of industry-led growth in Brazil began to be laid down during the first three decades of the 20th century. The spread of railroads brought with it the need for increased capabilities in civil engineering and greater technological sophistication in production and use of steel such as foundry, forging, and machining operations, and steam power. But the economy of Brazil went into depression with the economic crash of 1929 and exports of primary products collapsed, although domestic production of cement, chemicals, paper, metals, and textiles were stimulated. By the end of World War II, the country's manufacturing sector had become quite diversified though not very competitive by world standards (Dahlman and Frischtak, 1993).

During the period 1947-1964 one of the key elements of the industrial development strategy was to attract foreign firms to set up manufacturing facilities in Brazil by protecting the local market via subsidies and special treatment. By 1960, foreign subsidiaries accounted more than 50% of the capital goods producers, 70% of chemicals (except pharmaceuticals), 90% of pharmaceuticals, and l00%o of the nascent automobile industry, in 1951, the National Research Council (CNPq) was established to promote research in all areas. Especially harnessing atomic energy was perceived to be the key to military power and crucial for accelerating the process of economic development. It is no wonder that this choice has come at a time when the international relations were characterised by post war polarisation, competition, and conflict among countries.

During the 1964-1985, the military period, Brazil's efforts were directed toward planning for development and increased resources were allocated to science and technology. Particularly the First National Development Plan (1972-1974) was meant to achieve sustained industrial and economic growth based on the expansion of exports and domestic market. As part of a strategy of increasing national power, new areas such as nuclear energy, electronics, and space research, were expected to have rapid development. During the Second National Development Plan (1975-1979) the country entered a period of 'debt-led growth'. Brazil was determined to adjust to the oil-shock of the 1970s by deepening the process of import substitution and moving the country toward energy self-sufficiency. But even though the country managed to maintain relatively high rates of economic growth in the 1970s, it did so at the cost of growing macroeconomics imbalances for its foreign debt reached $100 billion by the end of 1985, the highest in the world. Ever since, the country is trying to correct the 'macroeconomic imbalances. The Cardoso government, in 1994, embarked on stabilisation plan. The Real Plan was undertaken as anti-inflationary measure, the economy is opened to competition, privatisation of public enterprises has been undertaken, and deregulation and import liberalisation have replaced the old import-substitution policies.

India started its rapid industrialisation project immediately after independence from the British colonial rule (1818-1947). But it has to be remembered that India had indigenous private entrepreneurship in trade, lending, textile and jute manufacturing even before the British period. That is why East India Company fought hard against other English merchants and other rival European merchants to control the monopoly of trade with India. During the colonial rule, Indian textile manufacturing lost their competitiveness because the des favoured British manufacturers at the same time that the industrial revolution was pushing the technological frontier. Therefore, India sought import substitutions strategies to accelerate industrialisation soon after independence. It even pushed it farther by giving priority to the 'heavy industry' as opposed to the 'light industry' because its leaders were influenced by the Marxian ideology.

In 1946, the textiles, sugar, vegetable oils, iron and steel, and general engineering industries dominated the industrial structure of India. These made 83.71 percent of total value added and 85.57 per cent of total employment (Bhagwati and Desai, 1970). To change this dominance of light industry and make India a real industrial power, the capital goods industry had to be established. The government had to own the means of production of these basic industries and as a result a new era of planned development started. The two major government organs in this endeavour were the National Development Council (NDC) and the Planning Commission (PC). The NDC consisted of the Prime Minister and the Chief Ministers of the States and the members of PC. The PC presented the NDC with lengthy and carefully drafted memoranda, which usually asked it to decide between alternative lines of policy. The commission had on these occasions come to its own conclusions, which pressed vigorously and for the most part successfully. Discussions did reveal just how much the states were prepared to stand for, and how far they were prepared to go in carrying out centrally determined priorities. It is possible to say that it was a forum where plans undergo adjustment in the light of the needs, pressures, prejudices, and capacities of the states (ibid.).

Therefore, the now mostly criticised bias towards the heavy industry was the product of these central-planning bodies. During the first four five-year plans (1951-1974) a consensus emerged on the nationalisation of defence industries and the ownership of public utilities while no divisions were obvious with regard to other key industries and the financial institutions, In fact, the Industrial Policy Resolution assigned monopoly by the state of atomic energy, arms, ammunitions, railways, iron and steel, shipbuilding, mineral oils, coal, aircraft production, and telecommunications equipment. The rest of industrial investments were opened to both public and private. The administration and control of such a planned economy proved to be very difficult and inefficiencies resulted in Indian poor industrial performance.

Towards the end of 1980s India was seeking a new approach with an increased emphasis on productivity and efficiency. The new path considered is the liberalisation of industrial Incensing, the import of capital goods and other commodities. The new policy favours freer growth of consumption goods as opposed to capital goods to redress the bias of earlier policies. Ghosh (1992) criticises the Indian development strategies for not paying adequate attention to the Schumpeterian concept of innovations' as the prime mover of industrial growth. The neglect of the private initiative and entrepreneurship, which is at the centre of innovation, was a major stabling block because India failed to establish conditions that would promote an atmosphere conducive to innovations and innovative enterprise.

The case of Taiwan is special. It was under the colonisation of Japan from 1895 till the end of World War II. After that it became part of China but soon was engulfed in the civil war. The nationalist party was fighting against the Communists to keep power but lost and retreated to Taiwan. It had to continue to strengthen the armed forces in order to defend itself from the mainland's China communists. It was on the verge of economic collapse by the mid-1950s. It was only to the American military and economic assistance, starting in 1954, that saved the country (Woronoff, 1992).The US acted in its strategic interest of controlling the spread of communism in Asia. But it is important to note here also the influx of refugees fleeing the advance of the Communists in the Mainland China. They were about 2 million people, It was a blessing in disguise for among them were a lot of highly skilled people: industrialists, bankers, doctors, administrators, professors, professionals, artists, and even chefs (Taiwan Survey, The Economist, November 7, 1998) that made a great contribution to the development of the island.

South Korea was under the colony of Japan from 1905 to 1945 which left some industrial base mostly in the northern part of the country. Between 1945-1953 a bitter civil war devastated the country's economy and the country has divided into two: North and South Korea. It is possible to see in this war the influences and the confrontation of capitalist and socialist camps. After the war, South Korea virtually had no domestic savings, and about 70% of all reconstruction projects had to be financed by foreign aid. American economic assistance averaged about 10% of Korean GM between 1953 and 1960, enabling the country to recover back to the pre-war period. By the time the aid was completely phased out, Korea launched its economic development program in the early 1960s (Kim, 1993 in Nelson ed.)

Singapore became a British colony in 1824 around the same time of that of India. It was part of the British colony called 'the Straits Settlements' together with the ports of Penang and Melaka. In 1946, Penang and Melaka joined the Malayan Union and Singapore became a crown colony. After a brief federation with Malaysia, 1963-1961 became an independent republic on its own. It is member of the Commonwealth. Soon after independence in 1965, Singapore was turned into an 'enclave' for the export of products manufactured by multinational firms and into an international financial centre, which controlled slowly the regional economy.

Hong Kong became British colony in 1848 and joined back China in 1997 under the arrangement of 'one country two systems'. Initially Hong Kong developed as a trading centre, providing an entry-point to China till 1950. Afterwards, after the communist victory in China, the US and Britain imposed a boycott on trade with China. This time signs the beginning of Hong Kong's rapid development of light manufacturing industries in textiles, garments, plastics and electronic products. In Early 1980s, Hong Kong trade with China resumed becoming the main gate to China again. It is also one of the largest financial centres in the world.

South Korea, Taiwan, Singapore and Hong Kong are known also as the 'Four Tigers' for - their exceptional economic growth shown in last three and half decades. In terms of per capita income, Singapore is fourth in the world and Hong Kong thirteenth, and the country to join the OECD countries is Korea.

Now that we have given brief country profile of the sample countries, we can proceed to see in brief the international relations of the cold-war era and the impact to the economic and technological development of these countries.

After the World War II practically the world was divided into two blocks: the capitalist block led by America and the socialist block led by the Soviet Union and China. The result was the 'cold war' which lasted until the collapse of the Soviet Union and its allays, the Eastern European socialist countries, in 1989. The period mentioned is very much known for the peculiar international relations that created. The whole international trade was shaped around it. Foreign investment and technology transfer followed the same pattern. Being member of either block was a prerequisite for access to capital and technology of that particular group. It is in this environment that developing countries had to work in the past decades. Allegiances were frequently changed with detrimental effects to socio-economic stability. It is possible to say that changes in government ideologies were immediately affecting the international relations, international trade, and access to capital and technology because everything was assessed in terms of security of a given group of the two blocks. At times you could say that countries had little room to manoeuvre their economic policies for fear of displeasing the group to which they belong.

The situation of India illustrates the effect of cold war to developing countries. The impact of the international relations during the cold war had an important contributing factor to explain the poor economic performance of India (Bhagwati, 1993). In the minds of the American intellectuals and elite, if China succeeded and India not would have meant a profound impact on the leadership of the developing countries pushing them ever more into the Soviet orbit of influence. This new threat posed by the Soviet Union had to be stopped, thus, it was considered in the American and its Western allies' interest to help the successful economic development of India. As a result India got support during the 1950s through the mid-

1960s. But after the Sino-Soviet split and the Nixon-Chou summit's 'Shanghai Communiqué' in 1972 calling for the development of trade and cultural ties, 'normalisation' of Sino-US relations moved into high gear. To this was added the Indo-Pakistani conflict of 1971, in which the US favoured Pakistan. These new developments ushered in an era where the Chinese economy would be viewed with indulgence whereas India's was perceived critically. The Chinese economic reforms of 1978 have greatly reinforced the predisposition to a favourable view of China's economic performance. But the collapse of the Soviet Union in 1989 and China's internal political reform that ended with the Tiananmen Square Massacre of June 1989 set the Chinese image back to what had been during the worst excesses of the Red Guards under Chairman Mao and the Gang of Four. But India was moving in the right direction in internal economic reform. This shows us that during the 'cold war' things could move to either direction depending on what was viewed as security threat to the capitalist or socialist camp.

Here, it is possible to cite SAST Report on India (1991) to corroborate the impact of cold war political relations to scientific co-operation and technology transfer arrangements. The report says that 'U.S. - Indian political relations have always been subject to tensions that have sometimes spilled over into commercial technology arena but have not until very recently affected scientific collaboration. A recent example is that in the early 1980s, Indian-US private sector co-operation and technology transfer arrangements came under the shadow of US Export Administration Regulations. During that period, the US imposed restrictions on the transfer to India (and 14 other countries) of an ever-widening range of "dual-purpose" technologies that they feared would find their way to the USSR, India's 12 year attempt to acquire a $12 million Cray XMP 14 supercomputer for meteorological, hearth, agriculture and physics research purposes got tangled up in this impasse. While a good deal of suspicious and unwanted attention was paid by the US to India's nuclear and space programmes for the same reason.'

On the other hand, it is possible to some extent say that some of the Southeast and Eastern Asian countries have benefited from it. To control the expansion of the Soviet Union and China, the West practically helped the Japanese economy and that of South Korea and Taiwan. The presence of the British in Hong Kong made very easy for the capital access and technology to this part of the world. The military presence of America in this region had in general influenced the favourable trade policies toward these countries by the West.

Compared to the above picture the experience of the Latin American countries is not all rosy. The heat of socialist political movement had caught many countries in this region. It was very hard for the United States to swallow. The classical example is Cuba at odds with the United States till the present days. Today the US is not only continuing the economic embargo but is pressurising even other western countries to do the same through policies and legislation. Now the 'cold war' is over. It seems that a real globalisation is taking place, National boundaries seem to be less relevant. The international trade is much more liberalised than any other time in human history. Even though developing countries cannot truly and fully participate in it because they cannot compete due to underdeveloped capacity, at least potentially the door is open to them. Now they have to learn and develop their scientific and technological capability in order to participate as equals in the already at hand global markets' Within this perspective, science and technology policy and management has to rise to its rightful place within the developing countries. There is no time to waste.

4.3 Science & technology policy

Let us now turn to the S&T policies and their role in the economic development policies. Besides, we will also consider the relationship of S&T policy, the institutional and human resource development. After that, implementation plans and management issues are considered within the major factors of the environmental context in which these countries were operating in order to have an integrated view. The 'melting pot' analogy has been introduced. This is the economic performance that results from the macroeconomic policies, S&T policies as carried out by the different enterprises and institutions (government or private) and the individual skills and entrepreneurial skills. Each of these elements may work together, confront each other, co-operate or pull in different directions depending on the situation'. The improved living standards and higher international economic competitiveness can measure the end result.

Vision and goals

Sometimes the expectation of mankind from science and technology is so general and unspecified that it looks as though societies merely replaced 'god' by 'science' in their prayer for plenty. This uncritical attitude may push the common man to be content to leave the solution of his problems to the new 'priesthood' of scientists and technologists without perceiving any participative role for himself (M.S. Gore and Suma Chitnis, 1979). Nehru had said that 'it is science and science alone that can solve the problem of hunger and poverty, of sanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources, running to waste, of a rich country inhabited by starving people. Who indeed can afford to ignore science today? At every turn, we have to seek it and the future belongs to science and those who make friends with science' (Ibid.). It may be said that this statement by Nehru captures well the perception found among the political leaders in the third world, particularly at the times of political independence of these countries.

Gore and Chitnis (ibid.) have, basing their argument on statements of scientists and scientific advisors, arrived at a list of six objectives of science which we also agree that these can be taken as, basically, the objectives of any developing country. They are the following:

1. I ' the eradication of poverty and fulfilment of the basic minimum needs of food, clothing and shelter for all;
2. industrialisation and economic development - the problem being visualised not only in terms of an increase in per capita income but also in terms of a reduction in unemployment, visible improvements in the standards of living, adequate provision of services for hearth and education, etc.;
3. self-sufficiency in the matter of scientific and technological know-how and a capacity for basic scientific research and technological innovation;
4. self-sufficiency in the matter of national security;
5. development of the capacity to make prudent use of the resources in the country - including the capacity to conserve these resources and to protect them from the ravages of the elements and from ruthless human exploitation; and
6. inculcation and dissemination of the scientific spirit and a rational temper.

In short, all of these countries want to 'catching-up' in terms of S&T development for economic development with the industrialised countries and to provide a good living standard to their people. This particularly meant mastering the scientific and technological know-how in order to use it to solve the myriad problems of their societies. Policy instruments were used to achieve these objectives. This is because markets work incrementally and all the required responses to price signals in terms of shifts in resources take time. If large changes have to be brought about in a short time, the system cannot be left to market forces. One of the reasons why the state is so eager to intervene in developing economy, as was the case in NIEs, is that there is a pressing need for rapid growth (Das, 1992, p.la4). Therefore, looking into policy making and implementation does help us to see the dynamics of state intervention and market forces. Balancing the two seems to have worked in the rapid development of NIEs.

Science & Technology policy.

Hicks (1981, p.28) argued that the mainspring of economic progress is invention, invention that works through the rate of profit. Each invention gives an impulse to the economy. The chain of causation is from investment to final output, from final output to wages, from wages to the rate of profit on new investment, and then back on investment itself - the latter step in the substitution of capital for labour (ibid. p.127). In this section, we are studying this chain of causation of invention to innovation and to the economic progress that is exhibited by the NIEs. We are looking to policies and implementation performance of S&T in relation the economic development support made by these countries.

If we see the Latin American countries experience there is a marked difference from the experience in the Southeast Asian countries. Brazil and other Latin American countries have used 'explicit' policies (see Appendix 2), during the last two decades, to raise awareness of S&T and have led to the adoption of some useful instruments. But the essential relationship between technology policy and the general macro-economic environment has often been neglected (Correa, 1995). If the general environment for innovation is not adequate, there is practically no 'explicit' technological policy able to redress the situation. The scientific capabilities, created to different extent in various Latin American countries, have not contributed much to the building up of innovative capabilities (ibid.). Although some countries have even legislated for the creation of a 'scientific and technological system', as in the case of Brazil, in most cases reality showed uncoordinated actions by various innovative agents, if not markedly contradictory aims and strategies. Governments were unable to provide appropriate funding for R&D activities and also failed in establishing an effective system of co-ordination and planning.

With regard to the purchasing power of state-owned enterprises and public institutions to promote industrialisation and innovation, which has frequently been stressed by all countries and some countries (e.g. Argentina, Venezuela) have adopted specific legislation on the matter, has not been effectively used. But there are some outstanding experiences (for instance, by the commission Nacional de Energia Atomica in Argentina, PETROVEN in Venezuela etc.).

According to Etzkowitz and Brisofla (1999), Brazil has had three basic plans for S&T development. The first (I PBDCT) covered the period 1973:74 programmed an increase in the volume of resources for S&T. The second basic plan (1975-79, II PBDCT) set some priorities including the development of new technologies in unconventional sources of energy, space and oceanography. Emphasis was also put on the development of human resources through the stimulation of new graduate programs in universities to strengthen the relative weakness of its universities. The third basic plan (III PBDCT, 1980-85) aimed at supplying S&T resources and reinforcing technological capabilities of national firms. Some sectors were selected as priority areas such as telecommunications, petrochemicals and chemicals (ibid.). But these attempts were fragmented and limited to few sectors, which the Brazilian financial crisis has brought almost to halt. The example of CODETEC (Company for Development of Technology) shows that. CODETEC was established by the State University of Campinas as incubator facility, technology transfer office and venture capital firm out of research conducted on the campus.

CODETEC had to change its strategy with the financial crisis in 1979 and could not continue as incubator. It changed to become a niche producer in the Brazilian chemical and pharmaceutical industry because the Brazilian S&T policies supported domestic industries in areas of medicines and tariff walls were raised to encourage substitution of local products for foreign imports. It got a large contract with the State Medicine Centre (CEME). Its main task -was reverse engineering and it established an information-gathering arm to draw upon the world scientific and patent literature, collating information to support its reverse engineering activities. But after 1986 with the coming of the civil government in Brazil and the open economy system that followed, CODETEC could not survive in the open unprotected market environment. Once again CODETEC had to change its strategy. It decided to develop and market fine chemical products and pharmaceuticals itself. But the sudden death of two of its key leaders left it without strong leadership at a critical time and began to slide into bankruptcy (ibid.). This shows the lack of integration of the various elements in the national innovative system of Brazil.

Latin American countries lack more comprehensive schemes to promote the diffusion of technologies, particularly in the case of pervasive technologies such as IT. Policies have generally focused on the supply side, and have neglected the extremely important aspects of dissemination of technologies that can increase productivity and global efficiency (Correa, ibid.).

Both Brazil and India, the large countries, showed heavy intervention in their industrial and technology policies. Brazil promoted several large public research organisations, and its giant public enterprises invested in research and development. It intervened in technology imports to support the development of local capabilities in the selected industries (the best-known case being minicomputers). Despite its heavy investments and major successes in some specifically targeted areas (aircraft, minicomputers, special steels, armaments), however, Brazilian strategy in technology development was to a large extent ineffective in achieving competitiveness for large parts of industry Dahlman and Frischtak, 1990). Mexico also pursued policies to build up domestic industry behind import protection, but did not adapt Brazilian-style interventions to develop specific technologies; it also lagged in the development of local capital goods. As a result Mexican technological prowess is generally considered to be behind Brazil's.

India's S&T policy is based on the concept of self-sufficiency and elimination of foreign technology dependence. For this reason, it went for a broad-based science and technology development. It led to the establishment of a large number of S&T institutions. At the same time selective excellence has been pursued.

At the beginning, the Indian strategy was based on the 'free play of the intellect' type of S&T development. It was not based on making India's economy more competitive internationally. The effort was focused on the establishment of broad-based S&T infrastructure in education, research and supporting facilities. Considerable energy of Indian scientists was spent in basic research rather than on research for immediate industrial applications. After 1970s, the policy shifted towards linkage between research infrastructure and economic progress. The National Committee on Science and Technology was established in 1973 and the first science and technology plan was prepared and integrated with the five-year economic plan of the country. On the industrial front, several policy changes were made with regard to the import of technology, the exclusion of foreign investment from certain sectors and the use of patents that influenced the utilisation of domestic R&D capabilities. As a result research focused on import-substitution and to promote in-house R&D in the industry, several fiscal incentives were introduced. This continued till mid-1980s. Afterwards, the increased dissatisfaction of the result of the Council of Scientific and Industrial Research (CSIR) labs in developing and transferring technology for use to Indian industry led to a number of restructuring and change in financing methods of such labs. But in general the liberalisation of the economy of the 1980s was a great help to the scientific community as well by way of greater competition, external co-operation and greater accountability.

India of the late 1980s and 1990s is still committed to increased investment in advanced technology, in solving its major socio-economic problems using its S&T capability, and in providing substantial boost to the private sector R&D capabilities. But during the last period, a number of 'technology missions' were launched and despite the promising start little has been heard of them; and the massively funded defence and space related research was unable to meet many of the technological development targets set for them. All of these are posing enormously difficult challenges for the Indian science policy to overcome.

The paradox is that India excels in certain S&T fields. The country has established expertise in space technology, oceanography, in wind testing and model building capabilities, in chemistry, in pure and theoretical science fields such as astrophysics and particle physics, pure and applied mathematics, surface studies and fast kinetics, and even superconductivity. It is to be noted also the country's growing capabilities in software and biotechnology. In all of these fields, if not a world leader, it is internationally competitive in basic and applied research. But due to a weak industrial capability, India could not exploit the full potential of its scientific capability for commercial purposes and, thus, contribute towards economic development of the country. Once again S&T supply side was growing while the demand side remained behind creating a mismatch, which is the main cause of ineffectiveness of the national innovation system of India.

Unlike India, South Korea, Taiwan and Singapore built their S&T institutions to strengthen their industrial production for international markets. Particularly Singapore, and to a lesser degree Taiwan, used foreign investments to develop their industrial technology base. Korea's strategy favoured technology based on domestic investment rather than on DFI. But all the three countries were focused on selected science and technology to build their international industrial competitiveness. At the beginning the three of them focused on labour intensive technologies to create their light industries in the 1960s, but during the late 1970s deliberately changed their strategies, in line with their changing comparative advantage in the international market, by moving towards the high-tech and knowledge-intensive industries. These three countries distinguished themselves as the best users of science and technology in a planned development of their economies. Hong Kong relied, on the other hand, more on the market forces and less interventionist approach to science and technology development. But comparatively is behind the other three in terms of scientific and industrial technology development.

Korea has adopted a dual approach of creating and rearing necessary S&T in parallel to the economic development of the country (Lee, 1988). S&T were developed by identifying the appropriate technologies to support industrial growth through direct and indirect government interventions. Up to 1985, the government was the main investor in science and technology development, while after that, the private sector took the lead in R&D investments. Now the policy is for the Government to take active part in the area of generic technology leaving the proprietary technology in the competitive hands of the private sector. However, the government retains and continues to strengthen inducement policy measures.

To give a brief evolution of S&T policy in Korea, before the highly advanced national (HAN) project in 1992 the country was following the 'bottom-up approach' while after that went for the new 'top-down approach'. In the past, national programmes designed and implemented by the Ministry of Science and technology (MOST) were usually run by government sponsored research institutes (GSRIs). Each researcher has to monitor technology trends in his or her field and submit research proposals, usually evaluated by peer-review method. Therefore, the choice of research problems was coming from below or the researchers themselves, which is called 'bottom-up approach.' But, since the researchers tended to pay attention to what is more fashionable in their fields than to research relevant to industrial development, national investment on S&T was not getting expected results. For example, according to Shin and Kim (1994), the Korean government made an R&D investment of US $207 million over the period 1982-1990 on 2,400 projects which were mainly proposed and carried out by GSRIs. While 30.9% of the projects jointly funded by the government and private firms were successfully commercialised, only 4.1% of government funded projects went to market successfully. As a result a better approach had to be found and the HAN project was launched. This is based on 'top-down approach' because before individual researchers submit their research proposals, as before, a national committee proposes both product-oriented technologies and basic technologies as priority for the country. After that MOST, Science and technology policy Institute (STEPI) of KIST, calls for research proposals. Proposals are reviewed by the specialist panel in each area and projects are selected. This ends with control and evaluation of R&D performance.

Taiwan, similar to that of Korea, focused on S&T of relevance to the development of a competitive industry. The programme is called 'Science and Technology Projects' (STP) to which the Ministry of Economic Affairs (MOEA) spends about 500 million US dollars every year. The five major parties involved in STP operation are government agent (especially MOEA), research institutions, industry, legislative Yuan, and academia. Government agent provides the resources. The legislative Yuan approves and audits budget. Research institutions execute STP. The firms cooperate in the developments of STP with research institutions or transfer the newly developed technology from those institutions. Academia plays the advising roles of planning, schedule monitoring, and result evaluation (Yang et al., 1997).

Given that Taiwan's industry is dominated by SMEs, industrial research was very weak. To redress this, the government established Industrial Technology Research Institute (ITRI) in 1973.The Institute for the Information Industry (III) was established in 1979. Its mission was to introduce and develop software technology, assist government agencies and public enterprises in their computerisation projects, train and educate information professionals, supply market and technology information related to the information industry, and promotes the development and usage of computer related technologies (Hou and Gee, 1993). Hsinchu Science-based Industrial Park (HSIP) followed in 1980. This policy of heavy government intervention in the development of S&T in Taiwan was considered imperative to sustain the future industrial development of the country. This is because as recently as 1989 about 95% of the SMEs in manufacturing industry did not conduct any R&D at all. Even the large manufacturing firms R&D started late, in 1987 were 13.5% and in 1989 39.3% (Xue, 1997).

The strategy of simple labour-intensive processing technologies that were dominant and successful during the 1960s and 1970s could not continue to be viable as the comparative advantage of lower wages were eroded. Taiwan saw this threat, as its direct competitor countries like Korea and Singapore did, have to move on to high-tech industries. The tradition of building industrial parks, Taiwan had built 71 between 1960 and 1990, was considered insufficient and HSIP was the answer. This science-based park is considered to be very successful experience and was from the outset firmly based on a strong and well-integrated relationship among universities, industrial research institutes and the industry.

To understand the current zeal and focus on information technology that we see in Singapore today, we need first understand the whole logic of economic development strategy that Singapore is following. Based on the past 30-years or so of economic development experience of Singapore, some authors have proposed a 'technopreneurial national development model'. The word 'technopreneurial' stands for technological and entrepreneurial. They argue that the government of Singapore has played the entrepreneurial role in leading successfully the country in developing its economy (H.K. Tang and K.T. Yeo, 1995). Singapore's development since independence has many similarities with an entrepreneurial firm.

The government shows the following common traits of entrepreneurs: opportunity pursuer, determination, dare, and innovativeness (see Table 4.5).

According to Tang and Yeo (1995) what Singapore did was to: build up its infrastructures, develop its human resources, and attract and gain confidence of investors with innovative and pragmatic policies. Depending on the opportunities available the government did invest selectively its limited resources in industries, which are strategic to the nation private since the local sector-is unlikely to contribute significantly due to fact of technological competence. During the 1980s, Singapore invested heavily in highly skilled manpower development and as a result the number of engineers and technicians graduating from universities and polytechnics increased substantially and has enabled the industry upgrading and R&D activities' Government target is to hive 20% of every year's cohort going to universities, half to polytechnics and the remainder receiving skills training in the institutes of technical education.

Table 4.5: Summary of strategic move by the Singapore

Time frame	Opportunities / problems	Response
2nd half of 1960s	Excess of low-skilled labour, lack of industrial heritage, political uncertainty in Hong Kong and Taiwan over China	Draw in MNCs which were searching for labour - intensive operation bases
Late 1960s	Pull-out of British military bases, boom in shipping passing Singapore, start of oil exploration in South East Asia	Established shipyards, and defence industry. attracted petroleum related companies
Late 1970s	Acute labour shortage, low productivity and low value-added	I0-year economic upgrading plan, rapid expansion of technical tertiary education
Early 1980s	World-recession, non-competitive factories closing down or shifting out	Pulled in MNCs in new growth industries
1986 to now	Other NIEs catching up in industrialisation and technological development, China India. Vietnam opening up, economic boom in Asia	Encourage entrepreneurship, overseas ventures and MNCs to use Singapore as regional hub. push for R&D and innovation Economic alliances to capitalise on the boom in Asia

During the last decade, the government of Singapore established nine research institutes and centres. These specialise in electronics, information technology and biotechnology, which are considered to be the technologies for future economic growth. Their mission is to provide specialised training, develop. pre-competitive technologies, provide services to companies, and transfer technologies to industry. in 1991, Singapore Science Council was upgraded to the National science and technology Board (NSTII), and National technology plan was published' on the other hand, the government of Singapore gives various types of incentives to attract investments into growth industries and promote automation, training and productivity' Moreover, offers new incentives to encourage companies to locate their upstream activities such as R&D, product planning and design to Singapore; and to strengthen the linkages among companies (both local and foreign) to form competitive industrial clusters.

Hong Kong followed the laissez-faire approach to technological development (Hobday, 1995). It is behind the other three tigers in S&T development in general. While the other three were busy upgrading their R&D and industrial technology, Hong Kong, after the opening up of China in 1980, was busy expanding its industry into China to exploit the low wage advantage based on the old system of labour-intensive simple technologies. But at the same time it was able to build financial and trade institutions of international class.

Both, Brazil and India, have worked under the import-substitution strategy in the development of their S&T. On the contrary, the Southeast Asian countries have basically worked under the export-led strategy. This allowed the presence of foreign competitors and has produced an additional pressure for enterprises to learn faster the required technologies and use them more efficiently and effectively, which was absent in the former situation.

Therefore, if we are looking for the best policies the answer is 'there is no a single best policy'. The experience of these countries clearly shows that countries have a number of possible policy choices. They should be able to identify the policies that suit their particular socio-economic, political, and natural endowments. A pragmatic solution to the dilemma of whether to go for a free market system or allow the state intervention is to go for both of them. When markets work, leave them alone. But if they don't intervene is as close as possible to the best strategy. The two are complementary and not necessarily mutually exclusive. But state intervention should be coherent with the market character, profit (including the social benefits) being its basic motive. We do have plenty of empirical examples from the NIEs where the state determined some sectors or industries are more important for the future growth of the economy than others and diverted resources to them with success.

In section 4.6, we will further discuss the S&T policies in relation to the economic policies and the result these countries have achieved.

4.4 Institutional capacity

In S&T development, institutions are very central. Institutions can be 'market institutions' and 'non-market institutions'. Market institutions are naturally created by the market mechanism itself. They are institutions established to give services with profit motives. The non-market institutions are created by the intervention of the government or other interested associations to achieve specific social or economic objectives.

Since markets are imperfect they cannot create spontaneously all necessary institutions required in a given environment. Thus governments intervene to create them. This same intervention is required, particularly in developing countries, to help the scientific and technological development of their countries. Usually governments create universities, research institutes, and training institutes because skilled manpower is considered as public good. Governments do establish sometimes 'special institutes' to promote the diffusion of science and technology (like science parks); funding institutions to provide finance the small and medium enterprise etc. Governments, through their macro-policy incentives, may encourage the creation of institutions for inter-sector co-operations between universities, research institutes, and private enterprises.

Table 4.6: Higher Education and Research Institutions in NIEs.

Country	Learned Societies, Research Institutes and Academies	Universities	Polytechnics and colleges
Brazil	135	74	59
Hong Kong	230	158	17
India	n.a	n.a	n.a
S. Korea	31	39	2
Singapore	28	2	4
Taiwan	68	18	9

Source: *The world of learning 1995, 45h edition, Europe publication Limited, London, 1995.*

Exploring the NIEs, we find a tremendous institutional capability created by these countries particularly in the past four decades. We will see how the NIEs have structured and organised their national economy in relation to the development of science and technology. In other words, we will try to see the various S&T institutions, economic institutions, and the government institutions of these countries to understand their interactions and determine the overall institutional capability created. In other words, we are trying to see the fit between all these various institutions created and the adequacy of the institutional infrastructure to enable the socio-economic development based on science and technology,

Based on the World of learning 1995, we can make a crude comparison of the extent of institutional capacity development in higher learning and research institutions in NIEs. But not all colleges and research institutions are listed. Particularly those that are designed for -local purposes usually choose not to be listed. The number of colleges in India and Korea, in particular, are underrepresented. The number of universities given is closer to reality because they want international recognition and make sure to be in the list. The same can be said of learned societies, research institutions and academies. If we see the number of university per million of population, we get 1: 6.08 million in India, 1: 2.22 million in Brazil, 1:1.5 million in Singapore, 1:1.18 million in Korea and 1:1.11 million in Taiwan. Again the advantage is of the four tigers. India has the lowest number of universities per population followed by Brazil. Roughly, where India has 1, approximately Brazil has 3 and the Southeast Asian countries have 6 universities for the same number of population. In absolute terms no country matches the number of universities in India. But number of institutions established cannot tell the strength and quality of such institutions. If we look to number of scientists, engineers and technicians engaged in research and experimental development, data are inadequate to make a real comparative analysis (Table 4.7). Anyway, the output of such institutions is what matters. One measure of S&T output usually considered is the number of patent applications filed (Table 4.2). The speed of diffusion of a technology and the exploitation of all its potential is also very crucial. This goes hand in hand with marketing and managerial skills as well. It is a very complex issue. What we will try to do next is to have some basic ideas of how the S&T institutions have evolved in the NIEs and what they are trying to achieve.

Table 4.7: Number of scientists, engineers and technicians engaged in research and experimental development in NIEs (full-time equivalent)

Country	Year	Total	Scientists % Engineers		Technicians	
			Total	%F	Total	%F
Brazil	1995	36,081	26,754	-	9,327	-
India	1990	224,773	128,036	6.0	96,737	6.3
Hong Kong	-	-	-	-	-	-
S. Korea	1994	131,587	117,486	8.1	14,141	-
Singapore	1994	11,384	7,086	-	4,298	-
Taiwan	-	-	-	-	-	-

Source: *United Nations, Statistical Yearbook, 42nd issue, 1997*

In Latin America, the region has created an institutional infrastructure on S&T and has deployed a set of policies in various fields with varying but in general limited success. Scientific and technological policies applied have often lacked the necessary differentiation between the promotion of science on one side, and of technology on the other (Correa, 1995). These institutions were conceived in most cases on the basis of a deliberate State intervention. But the inability of governments to sustain the funding of such institutions, particularly after the economic recession that hit Latin American countries after the oil shocks of the 1970s, made them less effective. Brazil did invest considerable amount of money in institutions to support the development and diffusion of S&T but the result was not satisfactory because these institutions either did not have enough power to make the desired change, or did not have enough resources to sustain the desired change.

These institutions were fragmented and could not be effective in solving problems beyond their individual capabilities and their conflict of interest could not bring them together. This indicates that the national innovation system of Brazil was not well integrated to create some kind of comparative advantage for the country, hence, the poor performance in the international market. Here, we should not or cannot disassociate the scientific and technological institutions from the macroeconomic management of the country. This is the context within which they are supposed to operate. In fact, in Brazil's case, it is the huge debt that sustained in the three decades of economic growth before the 1980s to cause the abrupt economic austerity measures that followed to kill the potential effectiveness of many scientific and technological institutions. Of course, the bias towards the basic sciences as opposed to the applied technologies and over-protection of industries from international competition are also the other major culprits.

At present, a new scenario is emerging in Latin America with tariff reduction and market liberalisation, together with a change in the role of the State both as regulator of the general economic activity and as supplier of services and goods. The premises that underpinned the scientific and technological policies of the last two decades are substantially altered. These trends, in association with a possibly strengthened system for intellectual property, are creating a new framework for innovative activities in the region (Correa, ibid.). This is considered like a fresh air long overdue. It is hoped that a more competitive environment would promote innovation. But there is a need to bring human resources in line with the actual demand to support a more market-oriented R&D effort. The right incentives for innovators and users must be there without creating problems to the long-term scientific development, which is the challenge to regulatory body where its institutional maturity will be tested.

We do have examples were Brazil has developed different lines to support local innovation, including almost all stages from product development to the setting up of quality control systems, the adaptation and acquisition of foreign technologies etc. It also supports national consulting firms. Currently Brazil is experiencing a serious crisis resulting from the drastic reduction in international financing and in the investment and maintenance programs of public enterprises.

With regard to Linkages between research institutions and enterprises, a range of instruments have also been established in order to strengthen the traditionally weak linkages between research institutions (particularly in universities) and the productive sector. To achieve this many Latin American countries, including Brazil, have taken a number of measures. Peru has included a special contribution (2% of net income) of industrial enterprises, Mexico and Colombia have created 'innovation' centres (sponsored by the Universidad Autonoma de Mexico) and (supported by COFCIENCIAS). Similarly Brazil has established a vast number of foundations and other entities, including enterprises such as CODETEC in Campinas associated to universities. Another interesting development in Brazil is the establishment of 'technology parks' or 'poles', often with significant support of the local states, aimed at creating scientific and industrial complexes. BIORIO, for instance, foresees the installation of about 70 biotechnological firms and a total investment of around US$100 million (Correa 1995).

In Latin America, in part taking advantage of the potential of information technologies, some efforts have been made in the region to facilitate the diffusion of scientific and technological information. One example is the database on patents operated by the Institito Nacional de Propriedade Industrial, which supplied almost 300,000 copies of documents in 1988, mainly through the 'Program of Automatic Supply of Technological

Information'. But during the 1980s, in Brazil, government expenditures for scientific and technological infrastructure diminished as a consequence of short-run stabilisation measures. The three main sources of funding public science and technology institutions (the National Fund for Science and Technology Development of FINEP and the budgets for basic research of CNPq and CAPES) suffered sharp decreases. In 1985 they were allocated only 40 per cent of 1979 amount. The same trend has been observed also in Argentina, Mexico, Venezuela, Peru and Chile (Bielchowsky, 1985; Sagasti and Cook, 1987; and Schmitz and Cassiofato,1992).

Here it is in place to look into the industrial technology development in Brazil. The structure for directing and promoting industrialisation in Brazil was first attempted by the establishment of National Development Council in 1956, with the initial purpose of acting as a central planning agency but later fragmented into several sectoral agencies called 'executive groups'. During this time we have the 'Targets Plan' that was a collection of five-year targets for output and investment in infrastructure, heavy industry, food and education. Particularly the import substitution policies of 1956-64 period favoured the development of the heavy industry sector mainly in the hands of the State Enterprises. But the local private firms were at a disadvantage in financial access. This state of situation was slightly changed, during the 1964-73 period, and improved financial facilities for the local private firms was provided. A new period of exceptional growth followed but became unsustainable because of macroeconomics imbalances resulting in heavy debt. It was during this period that Brazil established, to be exact in 1964, the Industrial Development Council (CDD. It was made up of representatives of the main economic agencies and was responsible for the co-ordination and establishment of criteria for the concession of fiscal and credit incentives to the manufacturing sector. CDI incentives were distributed at random, without any clear criteria, but to increase investments. Besides, CDI did not have much control over a dozen regional and sector-specific government institutions conceding similar incentives. A National System of Scientific and Technological Development (SNDCT) was set up to co-ordinate the existing S&T institutions, formulate S&T development plans and the funds came from the Fund for Scientific and Technological Development (FNDCT). Anew agency, the National Institute of Industrial Property Rights (INPI) was established in 1971 to screen technology imports to reduce the cost of technology imports and to facilitate its absorption. A new emphasis on higher education was also made (see Moreira, 1995,p.96-124).

Coming to the microelectronics industry, the policy of reserving the mini- and microcomputer industry for the Brazilian private capital have their origin in the Commission for the Co-ordination of Electronic Processing Activities (CAPRE) which was created in 1972 and had a regulatory role over information technology. Control over computer imports began in 1975, at which time a number of complementary policy measures were also set in motion (Piragibe 1985, 1988a; Tigre 1983). The beginning of the market reserve dates from 1977, when the mini- and microcomputers were reserved for the Brazilian private capital and the production of minicomputers was put to tender for national firms (Frischtak 1986:6). In 1979, CAPRE was transformed into Special Secretariat for Informatics (SEI) with a wider mandate. The protected market for national firms under SEI's guidance gradually spread to other areas, such as industrial automation equipment, micro-electronic components, digital instruments, super-minicomputers and others. In 1984, the market reserve and complementary measures were enshrined in the 'Informatics law' (Piragibe, 1988a; Meyer-Stamer, 1988). The main policy instruments used by SEI are quantitative import restrictions and the concession of manufacturing licenses to national firms. Foreign firms were limited to the production of mainframe computers. They were also controlled by SEI to the extent that the granting and withholding of import licenses can force these firms to have increasing indices of nationally produced inputs in their final products and also to show positive export balances (Piragibe, 1985). But starting from the early 1990s, Brazil has embarked on the road to deregulation and open market system.

The other big country among our sample NIEs countries is India. There is hardly any other developing country, and only a few developed countries that can rival India in the scale and spread of its scientific and educational institutional set up, writes Hoffman (1991). Since independence, the institutional structure for education and scientific research expanded enormously to more than 1000 research institutions, 157 universities and 5500 colleges. The number of in-house R&D units, both in public and private sector is about 1000, and that of consulting firms about 150. Out of a stock of nearly 3 million trained people, about 275,000 S&T personnel are economically active in S&T and by l99l some 90,000+ were directly engaged in R&D activities in various public and private sector R&D institutions (ibid.).

In India, the Prime Minister (PM) is the official head of S&T. There is a Science Advisory Council to PM, as well as scientific advisor and technology mission advisor to the PM. A Ministry of Science and Technology was created in 1985 with three major S&T departments: Department of Science and Technology (DSID, Department of Scientific and Industrial Research (DSIR), and the Department of Biotechnology (DBT). DST has the responsibility from formulating policy guidelines in S&T, the promotion of new areas of S&T, S&T entrepreneurship development and international scientific and technical affairs, including international S&T collaboration outside agriculture. The DSIR promotes innovative and R&D activity in industry. Under DSIR there is the Council of Scientific and Industrial Research (CSIR) whose network of forty laboratories constituted the core group of industry oriented R&D centres in India. Even though criticised for not being effective, they have created some outstanding human and institutional scientific capabilities that have not only contributed to Indian development but have also provided the basis for a wide ranging set of international collaborations with more than 40 countries. Moreover, there is conceivably a wealth of commercially valuable but still under exploited knowledge available in CSIR labs (Hoffman, l99l).

Councils similar to CSIR run research institutions under the control of other ministries such as the Indian Council of Agricultural Research (ICAR). This has a chain of 40 labs in agricultural and animal husbandry research, the Indian Council of Medical Research (ICMR) that formulates co-ordinates and promotes biomedical research, has 18 R&D institutions under its control. The Defence Research & Development Organ is responsible of all defence related research activities and controls and directs over 40 laboratories. Other departments with a strong S&T component to their activities who also support R&D laboratories are _ atomic energy, electronics, space, environment, non-conventional energy sources, ocean - development and education. In all the Indian central government, through its various ministries and departments, provides support to 1000 laboratories while the state governments support another 300 laboratories. In 1986, 55 percent of total S&T related expenditure went to the scientific departments while the S&T component of the socioeconomic ministries accounted for 45 per cent of the outlay (see Hoffman, 1991, Sast Project I Report on India, pp.57-9).

The founding fathers of independent India like Nehru have laid down the foundation of a vast number of science and technology institutions, which were expected to turn the country into just and prosperous society. The building of such scientific and technical infrastructure has grown to such immense proportions that India can claim the world's third largest workforce of scientists and technicians (Mahajan and Sudarshan, 1989), But the result was disappointingly small because high quality research is almost non-existent and overall quality of research has actually been on the decline during the 1980s, major discoveries and inventions have simply passed India by and even minor achievements have been few and far between (ibid.). The major criticism of Indian S&T institutions is the control of these by few who are extremely powerful and never held accountable people. The environment created was not conducive and attractive to curious, independent minded, fearless and dedicated young researchers. The existing separation of research institutes from the universities is another problem. The research institutes attract the best people due to better research facilities and rewards while the universities are left for the second rate people. As a consequence, the universities' quality of education is increasingly falling in all universities with few exceptions. To reverse this trend 'the best of the current scientists should teach, train, and inspire the next generation' (ibid.). Of course, the biggest single problem of India is brain drain to foreign countries, particularly the USA and needs a quick solution. May be the answer lies in the ability of India to expand the industrial research of the private sector as opposed to that of the public sector and government. As increased international competitiveness of Indian companies would create job opportunities for young and promising scientists and engineers and the reverse of brain drain could occur. As for now, Indian industrial innovation lags behind that of Southeast Asian countries.

In the case of Korea, a number of organisations played a major role in the accelerated economic development in the last four decades. Among which are the S&T institutions. The government of Korea is a major player as well. The president of the country and his staff are at the centre of economic and political power. The president was served by a small number of competent advisors, who were often more influential than high ranking officials, to provide detailed directions on policy making confined to basic policy direction without laying down the precise policy content (Das, 1992). At the next stage in the intervention mechanism come institutions like the Economics and Planning Board (EPB), the Ministry of Finance (MoF) and the Ministry of Commerce and Industries (MCD. The EPB not only acted as a national planning ministry but also controlled budget and administrated prices. It also decided on foreign loans, foreign investment and the transfer of foreign technology. The producers' associations worked also as government agents, that is, their consultations with the government were a two-way process. The MCI interacted with and kept surveillance over the operations of these associations (Michell, 1984). The producers associations prepared detailed plans and the MCI then gave them their final shape and monitored them. In all this process a close link between the executive and the machinery of economic policy was maintained (Das, ibid.).

Parastatals also play a significant role in the Korean economy, in 1960s these parastatals were partly the legacy of Japanese colonialism but the Korean government created others itself. They controlled many of utilities, like electricity, oil and coal, and industries like tungsten, steel, fertiliser, shipbuilding, air transport and tourism. They were generally import substituting industries or dealt in non-tradable goods rather than in exportable. The number of these enterprises increased from 52 in 1963 to 108 in l972.The privatisation policy brought this number down to 90 in 1984. Their share in value-added also increased from seven per cent of the GDP to nine per cent during the 1963-72 period, and remained around nine per cent level in the 1980s. Compared to the Korean private sector were less efficient but relatively efficient to the white elephant counterparts in other developing countries (Das, 1992, pp. 149-50).

Chaebols is a system of large, family-owned and family-controlled industrial conglomerates typical to the Korean economy. They emerged as a result of government incentives given to entrepreneurs to invest in new ventures to establish companies that could produce with economies of scale and compete with large competitors in the international market. As a result, they dominated the export industries. The government gave them financial, technical and structural support. Chaebols relied on government controlled credit institutions and usually played a supportive or subordinate role to the government. In l98l the Monopoly Regulation and Fair Trade Law was enacted to curb the dominant position of the Chaebols in the domestic market. The ten largest Chaebols are Samsung, Hyundai, Lucky Goldstar, Daewoo, Sunkyong, Saangyong, Hysoung, Hanjin, Kia, and Korea Explosives (see Das, 1992, pp 159-52). Now Chaebols contribute the balk of the industrial scientific and technological research expenditure in the country.

In the 1980s, the Korean government started directly funding the private R&D by establishing the National R&D Project (NRP). This was administered by ministry of Science and Technology (MOST) in 'new' technology areas focusing primarily on future problems, and the Industrial Base Technology Development Projects (IBTDP) administered by Ministry of Trade and industry (MTI) in 'existing' technology areas focusing primarily on current problems. Both institutions designate target technologies and offer direct R&D subsidy to R&D organisations. Tax incentives were also used as a major indirect funding mechanism for corporate R&D (Kim in Nelson ed.), 1993).

In South Korea, research activities in universities have been relatively underdeveloped. Though university expenditures increased significantly from $ 1.5 million in 1971 to $250 million in 1987, they accounted for only 5.4Vo of the nation's total R&D expenditures in l97l and 10.5% in 1987. Universities accounted for 33.1% of the nation's R&D manpower and 78.4% of its Ph.D. level R&D manpower in 1987. But to improve the situation, the government have designated five university R&D centres in 1989 that will receive increased financial assistance in order to strengthen their R&D capabilities (Kim in Nelson ed., 1993). The number of university students has increased from 131,354 to 931,884, with the proportion of high school graduates going to universities growing from 28.2 to 38.3 percent during the same period. This shows that these higher learning institutions are the backbone for the supply of highly skilled manpower in the country.

In contrast to that of South Korea, Taiwanese industry is in prevalence of small and medium - size enterprises. For this reason the role of government in promoting science and technology development for industry has become increasingly crucial for economic growth and export competitiveness (Paul K. C. Liu, 1992, in G. Ranis ed.). To respond to this need, the Executive Cabinet (Yuan) convened the First National Conference on Science and Technology Development, in 1978, and was attended by 400 top scientists, engineers, business leaders and government administrators to deliberate on the directions and strategies of science and technology development. Based on this conference in 1979, a Science and Technology Advisory Committee was established and the first Science and Technology Development Program was drafted, finalised and critically reviewed by the government agencies responsible for its implementation. Late on, this was integrated into the Eighth Four-Year Economic Plan (1982-1985). Conferences of this nature were held every four years to review and evaluate the performance of the economy and to make recommendations for future development. In 1982, second conference, the recommendations were to select eight strategic areas for technology development: energy, materials, automation, information, electro-optics, biotechnology, food and hepatitis control. The recommendations of the third conference, 1984, led to the formulation of the Ten-year National Science and Technology Development Plan (1986-1995) with a major goal of the improvement of general environment for science and technology development. The science and technology board is made up of distinguished scientists from both Taiwan and the USA and meets every year with relevant experts and officials to review and evaluate performance and perspectives.

The central government agencies in Taiwan play a dominant role in developing basic and applied science and in promoting science and technology research, the implementation of which they delegate to industrial associations and research organisations in both public and private sectors (Liu, ibid., p 383-4). The R&D expenditure in Taiwan has increased from year to year but the government has reallocated resources to higher levels of research with the intention of leaving product development research to the private sector which lately increased in proportion to that of the government. Of the R&D manpower in the eight strategic priority areas, more than one-third was allocated to information science and about one-fifth to each of automation and materials science, while the rest was thinly spread among the other five strategic areas. In the information science, efforts are being concentrated on the development of micro and minicomputers, peripheral and interface devices, and software utilising Chinese language. Efforts towards automation are devoted to the development of CAD and CAM systems that can be adapted to Taiwan's industrial mode Paul K.C.Liu, 1992, in G.Ranis ed.).

The experience of Singapore has its own peculiarities. The government played a very important role in the fast development of the countries' industrialisation. President Lee Kuanyew and his political part, Peoples Action Party, consolidated power and limited political opposition in 1967. With help of a small group of close economic advisors, including Go Keng-swee, Minister of Finance, the president of the country took direct responsibility for economic policy. The policy of import-substitutions followed in 1959 was officially abandoned in 1967 for export-promotion policies. Government agencies took a leading role in business through both direct and indirect means. For this reason some authors called Singapore 'administrative state' (Vogel, 1991, p.71), 'entrepreneurial state' (Sisodia, 1992), and 'corporate state' (Yuan and Low, 1990). State-owned or controlled enterprises were set up in oil exploration, petroleum refining, petrochemicals, defence, shipbuilding and airline travel. In the high technology export sector, including electronics, the state left most decisions to private firms, providing incentives, manpower training and infrastructure to attract foreign companies to the economy.

Singapore, to induce the TNCs, allowed a level of foreign control, which has not been acceptable in either South Korea or Taiwan. TNCs came to Singapore during the 1960s and 1970s to exploit the political stability, geographical location and efficient and constantly improving transportation and communications infrastructure (Hobday, 1995, p. 140). By 1990 more than 3,000 TNCs, among which 600 large firms, were operating in Singapore. In 1991 total manufacturing investment amounted to US$2.5 billion of which nearly US$1.2 billion (48 percent) was in electronics. By 1992 more than 250 electronics firms together sod in the region of US$19.4 billion in electronics. (Hobday, ibid., p. 141).

Hong Kong is considered by many to be more liberal and less interventionist than the other three tigers. Within its laissez-faire approach there were some government bodies to provide technological support to local firms such as the Hong Kong Productivity Council (HKPC), the Vocational Training Council (WC), the Trade Development Council (TDC) and the Industry Department (ID). The VTC is a statutory organisation, which operates eight 0echnical institutes and two industrial training centres that provide craft and engineering courses in electronics and related industries. The courses are in machine shop and metal-working, plastics, precision tooling, CAD/CAM and other subjects, whereas the TDC is responsible for promoting overseas trade. The TDC brings together industrialists, trade associations, senior administration officials and organises trade fairs. It also operates computerised trade inquiry service, providing product information by company for local and overseas buyers. The ID attempts to promote industrial investment by providing prospective investors with information on suitable industrial locations, labour searches, and other investment factors. Hong Kong educational institutes supply highly skilled manpower. The major ones are the University of Hong Kong, University of Science and Technology, and the Chinese University of Hong Kong (Hobday, 1995, p. 165-6).

This section demonstrates that countries can have institutions that suit their unique needs and characteristics. It is not necessarily said that there is one single best way of creating institutions. But it is a must to have well integrated institutions to succeed. These need be complementary and capable to support each other. Balanced growth of these institutions avoids the undesirable effect of having isolated world class institutions incapable to contribute towards the socio-economic development of the country. Particularly S&T institutions do require a considerable time and money to nurture them before they could be of support to the industrial development, particularly in the new technologies.

4.5 Human capital formation

At the time we were defining 'technology' we said that it includes also 'skills' or 'know-how'. This is possible only through human resource development. This is why in any serious attempt of technological development, training of the human resource becomes very central. It is possible to say that the issue of technological development is very much correlated to the extent of human capital formation or the availability or not of highly skilled manpower in that given country. We will explore, therefore, in short the experience of the NIEs. We have already given facts and figures on public expenditures on education, enrolment ratios at - primary and secondary levels, scientists and engineers, number of patents filed, and number of higher education and research institutions Table 4.2, 4.5, 4.6). Therefore, we need only continue to elaborate on other important aspects that were not brought forward before.

The human capital formation of a country is usually measured by the number scientists and engineers, professionals and technicians, and the institutional capability to produce such skilled manpower, which is captured by enrolments in educational and training institutions. Enrolment figures for education by themselves may be misleading. The true impact on technological capability development also depends on the dropout rate, the technical orientation of the students, and the quality of teaching. The dropout rate is exceptionally low in East Asian NIEs (Oshima, 1988; Kim. 1988).

Table 4.8: Indicators on human resource development in NIE's

Indicators	S. Korea	Taiwan	H. Kong	Singapore	India	Brazil
Edu. Expressed as a %household consumption (1980-85)	6	n.a	5	12	4	5
Public expenditure % GNP (year)	4.9 (1985)	5.1 (1986)	2.7 (1978)	2.9 (1980)	3.7 (1985)	2.9 (1984)
Gov't exp. on education % of total gov't exp. (1986)	18.1	20.4	n.a	21.6	2.1	3.0
% Age group enrolled (1985/95*)						
Primary	96/99	100/-	105/91	115/-	92/-	104/90
Secondary	94/96	91/-	69/71	71/-	35/-	35/19
Tertiary education	32	13	13	12	9	11
Vocational Edu. Enrolment (1984) in '000	815	405	32	9	398	1,481
As % population working age	3.06	3.24	0.86	0.5	0.07	1.83
No. Of tertiary level students						
Science / engineering fields ('000)	585	207	36	22	1,443	535
% population	1.39	1.06	0.67	0.89	0.21	0.40
year	(1987)	(1984)	(1984)	(1984)	(1980)	91983)
Engineering ('000)	228	129	21	15	397	165
% population	0.54	0.68	0.41	0.61	0.06	0.13

Source: Adopter from Lall (1992) Table 2.
Note: Years of data available are given in brackets, otherwise they are of 1992.
*Added data taken Aon World Bank, World Development Report, 1998/99.

Getting data from the literature to make a comparative analysis in human resource development achieved by our sample countries is very difficult. The closest we could manage to get is that prepared by Lall (1997, Table 4.8). In 1992, the proportion of each country's population enrolled in science and engineering is led by South Korea (1.39), followed by Taiwan (1.06), Singapore (0.89), Hong Kong (0.67), Brazil (0.4) and India (0.21). In 1986, government expenditure on education as a per cent of total government expenditure was highest in Singapore (21.6%) followed by Taiwan (20.4%) and Korea (18.1%). For Hong Kong data was not available while that of Brazil and India was way down 3% and 2.1% respectively. With regard to per cent of age group enrolled in primary in 1985 all were above the 90% with India at the lower end (92%)

and Singapore at the upper end (115%). But in 1995 of the three countries for which data is available, we see improvement in Korea from 96 to 99% while both Hong Kong and Brazil show a decline of exactly 10% from 105% and 104% respectively. Secondary enrolment in Korea increased from 94 to 96%, in Hong Kong increased from 69 to 71% while that of Brazil decreased from 35 to l9%. For the others data for 1995 is not available, but in 1985 Taiwan had reached the level of 91%, Singapore and India way down 35% (the same as that of Brazil). When we come to the tertiary, in 1985, Korea had exceptionally high enrolment of 35% while all the rest are in the range of 9-13% with India at the lower end. But this shows that India and Brazil have higher proportions of secondary schools graduates joining colleges and universities than that of the Tigers. Vocational education enrolment as Vo of working age population in 1984 was highest in Taiwan (3.24%) and Korea (3.06%) followed by Brazil (1.83%), Hong Kong (0.86%), Singapore (0.5%) and again India way down (0.07%).

The technical competence of an industrial workforce is improved by education imparted by various formal training systems and by in-firm training. While the precise nature of the benefits of vocational as opposed to general training, and pre-employment as opposed to post-employment training, is still the subject of debate Dougherty, 1989), it is indisputable that the speed of technical change in modem industry necessitates increasing inputs of training and retraining. Therefore, the flexibility and ability to quickly adjust and adapt to changing demands of skills a given country has becomes very crucial in maintaining the human capital stock.

The East Asian NIEs have the largest stock of human capital in a broad sense (formal education at secondary and tertiary levels) followed by Brazil and India clearly at the bottom. In training, South Korea and Taiwan are clear leaders (with South Korea lulling ahead at a generally high level, and Taiwan ahead in engineering education), with Singapore close behind. Hong Kong comes next, followed by Brazil with India again lagging well behind. In terms of the quality of education, patchy evidence suggests that the East Asian NIEs, with their strong cultural emphasis on education, are ahead of the others. In firm level training, South Korea is likely to be the leader while Singapore leads in employee training provided externally. These figures are in relation to the countries respective population size and not in the absolute sense.

While the most successful countries have the largest investments in human capital formation, preceding and accompanying their industrial growth, South Korea and Taiwan are in a different class from Hong Kong and Singapore. South Korea and Taiwan's larger relative -technical skill endowments explain their greater ability to tackle more complex and demanding industrial technologies. Hong Kong is distinctly behind Singapore, which confirms to the observed differences in their industrial structures and technological prowess. Interestingly, Singapore's heavy reliance on foreign investors in its high-technology industries does not relieve it of the need to provide educated and trained technical labour. Multinational corporations are able to set up such industries there only because of the availability of highly skilled personnel. Singapore is widely regarded as having one of the 'World's best employee-training systems.

India's substantial lag in human resources may appear surprising because of the general aura it has of a country with an oversupply of technical and educated labour. There is certainly a large absolute supply (although of highly variable quality), and graduate unemployment and emigration are real problems. In relation to the size of the economy, however, the stock is poor', and what seems to be concentrated in the larger establishments. The apparent oversupply is more a reflection of the economy's poor performance than anything else, wrong policies have held back even the absorption and effective utilisation of its meagre human resources (Lall, ibid.).

The empirical evidence and common sense are in agreement that without skilled manpower there is no technological development. And skilled manpower is the result of considerable investment and long time commitment and not something that happens by pure chance. Assuming even that you have limitless money, you can buy all kind of machinery, equipment, and blue prints immediately but you cannot change your unskilled labour into skilled manpower as quickly as that. People take time to learn skills. If we see countries oil rich like Saudi Arabia, they could buy any sophisticated machinery, equipment, entire plants, build entire new cities etc., but they had to heavily depend on expatriate experts and skilled labourers. Even today, after years of investment on their own people, they are still dependent on foreigners. Therefore, technological development depends very much on the degree of your ability to develop your human resources and takes time to mature.

4.6 The Melting Pot: Technology management and economic development

Good policies by themselves cannot help developing countries achieve their objectives. This is only the beginning. Therefore, good S&T policies must be matched by good science and technology management capability. But good policies and S&T management capability are the function of highly skilled manpower and institutional maturity. In this section, our main aim is to see the interaction of economic policies and plans, S&T policies, institutions and skilled manpower in the development of an internationally competitive economy.

Now, let us see the experience of our sample NIEs in the management of technologies. In the context of developing countries, S&T should primarily serve the economic and social development objectives; hence, they need to be carefully linked so that scientific and technological knowledge is used for innovation to make the economy more internationally competitive. But since innovativeness is based on entrepreneurship, this must be cultivated by creating an environment conducive for the entrepreneurs. Developing countries try to use a number of institutions, government and private, to support each other in the process of learning to catch up the advanced countries which should hopefully end up in an enhanced international competitiveness. In this section, therefore, we will particularly see how the organisation, networking, learning, are managed to result in greater competitiveness.

Organisation can be applied to countries. When we say 'organisation' we are referring to how a given country organises its resources (human, capital, natural endowments, and the institutions) to enable create a conducive environment for the creation of goods and services of value to customers in or outside the country. Our assumption is that the process of organising resources happens through the initiative of the government, the market or both, in line with the main objective of this research, the focus will continue to be on S&T in relation to socio-economic development. Practically, the creation of organisations for the supply of goods and services leads to the institutionalisation of activities. The two overlap in many respects. This is why we have given an account of the major organisations, such the government and S&T, under the previous section on 'institutional capability' (section 4.3). Therefore, we will proceed to give brief account for each country in our sample NIEs if there is a more or less integrated system of national innovation. In the process, we will be able to say if a particular way of organising the national resources allows the achievement of best results.

The balk of S&T effort in Brazil has been at the initiative of the government because up to recently the big institutions and enterprises were in the hand of the government. Despite a growing awareness of the importance of S&T for development, innovation and technology transfer overall expenditures in Latin America in general are modest (Correa, 1995). Public expenditures on R&D fell abruptly in some countries, like Mexico and Chile while in Brazil in 1985 the three main financing institutions for R&D received funds equivalent to around 40% of the 1979 budget. Nonetheless, Brazil accounts for 53% of the R&D expenditure made in the region, and, together with Mexico and Argentina accounts for 807o of the total. In addition, such expenditures are mostly concentrated on 'research' rather than on 'development' and are mainly made by the public sector in relation to agriculture and hearth. The linkage of such R&D activities with productive needs is currently weak. A low patent activity and the scarcity of scientific and engineering personnel devoted to R&D also characterise the prevailing situation. The 'import-substitution model' that characterised the industrialisation process in Latin America has, in particular, promoted 'minor' innovation based on adaptations and improvement of imported technology, rather than on endogenous R&D efforts. Transfer of technology continues to be an important channel for technological innovation.

Brazil has made significant efforts, both in the public and private sectors, to incorporate S&T as a tool for growth and progress. In terms of percentage of GNP, Brazil presents the highest investment in the region, about 0.9% of the GNP (ibid,). If we look to the structure and organisation of S&T institutions in Brazil, we find that the public enterprises have been among the most active entities. For example, the six big public enterprises - Petrobras, Cia Vale do Rio Doce, Electrobras, Siderbras, Telebras and Nucleobras - concentrate around 80% of the R&D expenditures made by about 500 State-owned companies (ibid.). This kind of national resource organisation is particularly identified with the military government period from 1965-1985, which was a period of strong nationalist thinking among the ruling class. This is the reverse of the structure observed in Brazil after the World War II, which was characterised by the strategy of attracting foreign investment while at the same time subsidies and special treatment were used to protect local markets. But now after 1986, a more liberal thinking is leading the country towards the market friendly structure with - increasing privatisation and reform of the public sector. This trend is expected to see the shift of R&D activities from the public institutions to the private enterprises, though government expenditures on R&D will continue in the foreseeable future.

The case of India is another very interesting situation. Indian S&T development is mainly established, managed and controlled by the government. The private sector does not play any significant role. But this country that has been able to develop world class institute of technologies and R&D institutes has not been able to tap all the scientific and techno Logical outputs for commercial development and international competitiveness with the exception in a limited software market. The Industrial Research Institutes (IRIs) have been established to promote indigenous technological know-how and helping enterprises introduce new processes and products. But many IRIs have had only limited success in developing technologies of interest to potential user enterprises, i.e. their technologies have no or only a limited commercial use (Katrak, 1997). One of the reasons why the IRIs failed is explained by the fact that IRIs personnel are said to have been more interested in experimental efforts that are mainly of interest to academic peer groups rather than to producer enterprises (Katrak, 1994). This is because they were more interested in getting recognition from the scientific community through publications. This hides also the lack of proper organisation and control as well as motivation of personnel in the IRIs to avoid the conflict of interest. But IRIs have shown some improvements in recent years because of the general macroeconomic changes in the country liberalisation of industrial licensing and foreign trade restrictions) and the way IRIs are funded by the government. Now the government of India requires that the IRIs cover part of their expenditures from their earned revenues (Katrak, 1998).

The fact that India, with a world class scientists and engineers, have not been able to grow fast economically as the four tigers have puzzled many economists. One possible explanation is because of India's multiple controls of its macroeconomic policies that resulted in large price distortions and led to inefficient use of resources. These controls have led to microeconomic inefficiency that made it easier to attain macroeconomic balance creating a micro-economically inefficient and macro-economically perverse economy (Joshi and Little, 1994). On the other hand, it is possible to blame the government for the poor performance because of patronage and spoils. In the government there is much confusion about what constituted a reform, what needed to be done, what was progress and what regress that one can easily conclude that the 'killer machine in India is the government bureaucracy' and red tape (Desai, 1993). This is showing again and again that science and technology development should be an integral part of the country's micro-economic management.

In Korea, government institutions, such as the policy-making bodies and other economic units like the commercial banks, together with the Chaebols have been able to create a unique institutional environment for the creation of the economy of scale in mature technologies. In turn, this institutional arrangement has enabled Korea to develop 'strategic industries' for an export led internationally competitive economy. The arrangement was that the Korean government sold all Japanese colonial properties and state owned enterprises to selected local entrepreneurs (the Chaebols) with a favourable long-term instalment payment and allocating scarce foreign exchange and preferential financing at the official ratios, half the real market rate (Kim, 1993, quoting Jung, 1989). Besides, the government gave them large import substitution projects (government purchasing power) and guaranteed their foreign loans, which were used to finance the imported production technologies on turnkey basis of the Chaebols (Kim, ibid.). But the Korean government was rewarding only good performers and penalising poor performers. The government was also using its commercial banks to punish poorly managed firms by freezing bank credits. When the time was ripe for new technology product development, the government through its various science and technology institutions and universities together with in-house R&D of the Chaebols gave the necessary push to make the risky leap to enter competition at the technological frontier. The best example is the semiconductor industry where they made leapfrog into the top ranks of dynamic random access-memory DRAM) producers (Cho, Kim, and Rhee, 1998).

This unique symbiosis in Korea has affected the structure of the industry and market, which is dominated by oligopoly (the Chaebols). Some rethinking is going to be necessary. Recently the Economist called South Korea 'East Asia's most controlled and distorted economy, dominated by the bloated Chaebols'. That made Korea less flexible for change at such times of difficulty, so its economy is likely to have a tough time over the next few years (The Economist March 7, 1998). This shows us that the Korean economy structure needs a rethink so that big and small businesses could co-exist in mutual support with no price distortions to serve the interest of a particular group at the expense of the others. Parallel to the fast industrialisation policy and the unique oligopolistic industrial structure that resulted, S&T institutions to support the industrial development of the country were also flourishing. Korean Institute of Science and Technology (KIST) was established in 1966 and the Ministry of Science and Technology (MOST) followed a year later in 1967.

Under MOST the national innovative system of Korea grew tremendously. In l97l Korean Advanced Institute of Science and Technology (KAIST) was established with the mission of developing highly skilled manpower for the anticipated growth in demand for R&D scientific personnel in the country. Korean Scientific and Technical Information Centre (KORSTIC) was restructured in 19'12 to function as information clearinghouse by collecting, processing, and disseminating scientific and technical information for international transfer of knowledge to both industry and research organisations. The national Council for Science and Technology under the chairmanship of the Prime Minister was established in 1973, which later was replaced by the National technology Promotion Conference and Technology promotion council in 1982. The conference is chaired by the President of the Republic and carries the weight of utmost national importance. It includes about 200 people from the cabinet members, industrialists, and scientists and engineers. The Technology Promotion Council is composed of vice ministers and relevant agencies and appointed civilians representing concerned organisations, deals with more practical policy issues. MOST serves as its secretariat, and its minister often presides over the Council on behalf of the President when he himself does not. The Korea Science and engineering Foundation was established in 1977 as a funding agency to support university basic and applied research. Daeduck Science Town was developed in late 1970s to accommodate most of KIST 'satellite institutes' designed to specialise in an area of high industrial priority such as shipbuilding, marine resource, electronics, telecommunications, energy conservation, machinery and metals, and chemicals together with central laboratories of private enterprises. The Korea Technology Development Corporation was created in 1981 to foster technology-based firms. A few more firms followed, some under complete private ownership. All the above and the over 400 private industry research institutes with the public sector institutes and universities complete the picture of the 'national innovative system' of the country.

Looking into the Taiwanese economy and institutions that made the success possible, we can identify three important groups of players: The government agencies, the myriad of SMEs, and the TNCs (including joint ventures) and foreign buyers. The SMEs created a network of interdependence and formed a complementary character with TNCs and foreign buyers, and among themselves in a unique way of forward and backward linkages that distinguishes it from the other Tigers. The government of Taiwan promoted industry through direct intervention in the complex technological fields and intermediate goods and through financial support. But the light industry was left to the market forces.

ITRI and III were used by the government to promote industrial technology research and specifically HSIP was meant to push the development of high-tech industries. HSIP was established to enjoy easy access to major cities, airports, and seaports; well known ITRI and two technically oriented research universities are in its immediate vicinity. It was designed to attract highly trained and experienced scientists and engineers, both within Taiwan and abroad, create a conducive environment for industrial R&D and the development of high-tech industries. By the end of 1992, the government invested us$461.5 million for HSIP. It is considered to be successful for high-tech firms grew from 7 in 1980 to 148 by November 1993. The annual aggregate output of HSIP in 1992 reached the level of US$3.35 billion (ibid.). In 1997, the target industries to be developed in HSIP were integrated circuits, computers and peripherals, telecommunications, opto-electronics, precision machinery, and biotechnology. The success of the HSIP project is also attributed to government generous tax and financing policies, which are considered to be more attractive than that of Japan, Singapore or Korea (ibid.). ITRI is very active in the HSIP. With its I0 research laboratories and research centres and more than 5000 highly skilled technical professionals, in 1997 out of the 99 firms created by Taiwanese capital in HSIP 14 were ITRI spin-offs (Xue, 1997). Tax and financial incentives were also used to encourage R&D efforts by the firms. But the most effective way by which the government can promote technology development was considered to be educating more R&D people, co-ordination among firms to do joint research, technology transfer from abroad or government-sponsored research institutions, and helping firms establishing their own brand names (Hou and Gee, 1993 in Nelson ed. 1993).

In a recent survey on Taiwan, the Economist, while explaining why this country is doing better than all the other East Asian countries in recession because of the Asian financial crisis, says that it is because of fear. Taiwan knows that it cannot afford to go bust. As a diplomatic pariah, it is banished from virtually all-important international organisations, including the MF. If it goes bust, it cannot hope for a bail out. Indeed, it worries that in the event of a domestic economic crisis the mainland China might just do what has always wanted to do, to invade it (The Economist November 7, 1998).

It is possible to say that this fear has moulded the Taiwanese institutions in a unique way. It has the world's third-largest foreign reserves and one of the world's lowest foreign debts. Its banks have the lowest bad loan ratios in Asia, and its companies have the lowest debt-to-equity ratios, It never fully abandoned currency controls (ibid,). It is in this macroeconomic environment context that the SMEs - that make to 98.5%o of the country's companies, 75-80% of all employment and 4'l9o of the total economy - operate (ibid.). These 'army of ants', as they are called by Taiwanese government economists, are infinitely flexible. They can switch businesses as market conditions dictate. They specialise in niche markets and you see them collectively create a critical mass, or 'cluster economy', that makes up for the marketing inefficiencies of each undersized member in a way that local subcontractors can usually be found for everything a particular firm needs to produce its speciality. This has resulted in special web of business networks in various industries (ibid.). During the 1970s and 1980s the Taiwanese government provided technical support to industry through government owned R&D institutes and universities and also invested, selectively, in a small number of companies working in scale-intensive, high-technology upstream sectors such as semiconductors (Hobday, 1995, p.98). The country can be considered as a good example where the market forces and government intervention work hand in hand.

Singapore has achieved a lot in the last four decades more than any country can dream because of the governmental vision, a partnership with multinationals, and an orientation toward the future based on technology management and the effective use of information technology (Sisodia, 1992). It is truly a corporate-government. The civil service personnel are highly trained for each year the top 3Vo of college graduates are targeted for recruitment and civil service is highly computerised. Not only the civil services recruits the best people but all government employees receive annual bonuses based on the performance of the Singaporean economy (ibid.) because they are the ones that influence the direction of it. The government of Singapore has even gone farther by recruiting professionals and scientists from all over the world. According to National Science and Technology Board, companies will need 2,000 additional scientists for the existing research and development activities over the period 1996-20ffi. The Economic Development Board (EDB) has set up programmes to help companies go overseas. In 1995, the EDB led seven recruitment missions to the US, Britain, India, and Australia for 50 Singapore-based companies. It facilitated the arrival of 2,127 scientists, researchers and entrepreneurs, and another 5,563 skilled workers, mainly from China and India (Far Eastern Economic Review, June 6, 1996). The government has been able to forge an excellent partnership with TNCs by providing world class infrastructures and skilled manpower. Over the years, the government has also been able to build local technological capability, which is now trying to achieve maturity by having their own design manufacturing capabilities. They have made considerable progress in the information technologies. Efficient government institutions and a well managed macroeconomic with TNCs partnership have made the country a model for many others in the world.

Hong Kong government was known for being non-interventionist. The country has been able to build an internationally competitive manufacturing industry (light industry less technology intensive) during the 1950s, 1960s and 1970s. After the Chinese economic reform and greater openness in 1978, Hong Kong restructured its industries to take advantage of new opportunities offered by China. Many manufacturing enterprises moved their plant to Mainland China to exploit cheaper factors of production such as labour and land. As a result in 1980, its manufacturing sector share of GDP declined to 9% from 25% while that of the services sector increased from 67% to 85% becoming increasingly service-based economy (Dodsworth and Mihaljek, 1991, MF). By 1997, over 500 banking institutions were present in Hong Kong, including 82 of the 100 largest banks in the world. It is the fifth largest banking centre in the world, fifth in the world in terms of foreign exchange market turnover, and the seventh largest in the world and second largest in Asia in terms of market capitalisation (ibid.). The success, therefore, enjoyed by Hong Kong is the result of the institutions it has been able to create and sustain. It has a lean and efficient administration, sound and transparent legal system and free information flow. It has a simple and stable tax - system with low tax rates, a stable exchange rate with the Hong Kong dollar linked to that of US (though at this time of recession is giving it hard time), and financial sector with suitable institutional and regulatory framework left to the market (ibid.). But it has to redress its technological disadvantage in the manufacturing sector to match the competitiveness of the other Tigers.

The success of some developing countries or firms shows that developing technological capabilities is possible but not necessarily inevitable. Emotional decisions may prompt developing countries to go for the latest technology. May be that makes them feel that they are on equal footing with developed countries. But buying a technology without understanding how or why it works does not lead far. They will enter a vicious circle of buying every time new expensive technology just to keep up without a real technological capacity development. Therefore, developing countries should first understand what technological capabilities they want to achieve in exact terms. Then, they should choose to acquire the right technological package, assimilate, improve and adapt it to their own needs, and at a later stage may go to final stage of generating new technologies to compete directly in the global markets like some Southeast Asian Tigers have started doing.

More important than the differences in the methods (Appendix 3) of transferring technology is the manoeuvring possible within each method (Dahlman et al., 1987). The point is clear; the technological benefits to be gained from foreign technology depend less on the method selected for the transfer and more on how the method is implemented. The method determines the structure for the transfer, but the room for manoeuvring within the method suggests that developing countries should avoid blanket policies for or against various methods.

The most important thing is to know how to get what is needed from each transfer, whatever the method of transfer. The idea is to use the transfer as a stepping stone to develop new technological possibilities. The main areas of manoeuvring relate less to technological means more to technological information and understanding.

The environment in which firms operate in the developing countries should have appropriate incentives and penalties as well as specialised technological agents to encourage the national technological capability development. Governments' role is establishing an environment that stimulates firms and specialised technological agents to etl.ga1e in ongoing technological efforts and develop added technological capabilities. Governments can also intervene directly to induce choices of techniques that are socially most appropriate, foster imports of technology on the best possible terms, and stimulate the development of specialised technological agents (Dahlman et al., ibid.). For example Brazil and Mexico have set up technological information centres that charge private users only a small fee for access to their data banks. They have also agents that subsidise the costs of feasibility and engineering studies for projects. Those agencies also subsidise technical training and equipment purchases by the consulting firms that conduct these studies.

Resource limitations do not allow countries to embark simultaneously on the development of technologies in every sector of their economy. It is a must, therefore, to be selective in the science and technology policy development. How to make such selection is often a very difficult question. Nonetheless, it should not be difficult based on the analysis of the strength and weakness of a given country to select the technologies with the most impact in the development of the economy in order to exploit opportunities available in its environment. But this is not all. The other government policies such as trade and industrial policies should support S&T policies and not militate against them. Therefore a great deal of synchronisation and co-ordination effort from the government side is required among all the policy instruments in its hand.

We can find good policies that have failed whether it is in developing or advanced countries. Good policies are not guarantees for success. But inappropriate policies, no matter how best you implement them, cannot get the expected result.

Data on total R&D expenditures, R&D performed by enterprises and patents taken out by residents show that the Asian NIEs are better than Brazil, or India. The technological data broadly support the trends revealed by the figures on education. The Asian NIEs, in particular South Korea and Taiwan have invested not only in educating and training their populations, but also in technological innovation. This investment was primarily oriented to the commercial needs of productive enterprises, and has drawn upon a large poof of scientists and engineers. Combined with a highly skilled workforce these investments yielded the competitiveness and dynamism that revealed in growth and export performance. Export orientation played a permissive and stimulating role, and as such was necessary - but it was not sufficient. On the other hand, India's industrial strategy has remained highly interventionist within its import substitution orientation. The Indian government was suspicious of private enterprises in general, and large private firms and foreign investors in particular; and barriers to entry, exit, growth and diversification were rife. It set up a large network of science and technology (S&T) institutions, but these were divorced from manufacturing enterprises and excessively bureaucratic. The administration of Indian policies was slow, complex and prone to corruption. Recently, the Indian government is opening up its market to foreign competition cautiously. Brazil has set up large public enterprises and restricted foreign entry in certain sectors to protect indigenous learning. The heavy reliance of these countries on MNCs for a great deal of advanced technology may well have pre-empted indigenous capability development in the sectors concerned. India has had a very different experience, excluding MNCs in much of manufacturing, but also suffering technological lags and inefficiency as a result of its trade and industrial policies and poor labour productivity.

In understanding the mainspring of economic growth in the Asian NIEs the role of innovation is also central (Fransman, 1984). However, in the case of these and other developing countries the innovative impulse comes primarily from outside, through technology imports. These imports are financed through foreign exchange earning of exports and in turn they enable further increases in productivity for both the domestic market and exports. Accordingly, exports influence economic growth, not only through direct dynamic effects, but also indirectly through the import of improved processes and products. However, it is now recognised that the successful import of technology is a far more complicated process than was believed. The experience of the successful Asian countries shows that in general it is the reverse process of what happens in the developed world. Instead of fluid-transition specific (Utterback and Abernathy, 1975), it becomes acquisition-assimilation-improvement (at a later stage, generation) (Kim, 1980, 1992,1998, Jinjoo et al., 1988).

There is no doubt there are numerous ways of organising national resources and institutions to increase national science and technology capability to support industrial development and -gain international competitiveness. Each country in our sample is different given the 'difference in their historical and political economy thinking of their respective leadership.

Organisations interact with each other to be able to create and consume goods and services. As a result complex web of interactions emerges, which we call networking. In the national innovation system of a country there is a network through which products move and sustain the whole system. In this section, we will focus on this specific aspect of our sample countries.

In Korea the National R&D Projects (NRPs) and Industrial Base technology Development Projects (IBTDPs) were used to bring about public R&D institutes and industry co-operation with limited results. In some cases, large firms shied away from receiving public support in recent years in order to keep their R&D activities confidential. For this reason the programs, now, largely support small and medium-sized firms. Given the teaching orientation of almost all universities, there is fundamental lack of co-operation between the universities and the private sector. Korean universities suffer from insufficient facilities and their faculty members have neither the time nor the incentives to undertake serious research, as a result, universities have lost the confidence of the private sectors, drawing almost no research funds from business circles. The move by the government to open its NRPs to universities to promote university-industry co-operation, it still remains insignificant. But informal collaborations in the form of consulting services provided by individual faculty members are quite prevalent. The government offers various tax incentives to promote industrial R&D cooperatives. It is a major form of inter-corporate R&D co-operation. By mid-1989, 46 industrial research co-operatives were founded involving 986 firms, 759 of which are small and medium-sized firms. NRPs and IBTDPs are used as instruments to bring about effective inter-corporate R&D co-operation (see Kim, 1993).

The Taiwanese electronic industry benefited considerably from TNC investments, joint ventures and foreign buyers. TNCs helped to foster the start-up of many of Taiwan's electronic makers as large numbers of local firms supplied them with goods and services, leading to a thriving sub-contracting and original equipment manufacture (OEM) system which was soon followed by own-design manufacture (ODM) and own-brand manufacture (OBM) (Hobday, 1995). The Taiwanese case shows how hundreds of tiny latecomer firms clustered together behind the electronics frontier to exploit market opportunities, indicating that the large-scale, mass market approach followed by the Chaebols is not the only route to export success for developing countries (Hobday, ibid.). Hobday shows that in Taiwan a clustered network of small firms in electronics, sewing machines, footwear, bicycles and other fast-growing export industries made themselves indispensable to foreign buyers and TNCs and forged backward linkages to other industries, Taiwanese industry is made up of at least five strategic types of firms: Foreign TNCs and joint ventures, the major local manufacturing groups; high-technology start-ups; government-sponsored ventures; and the large number of traditional SMEs which clustered together to exploit market niches.

Among the major TNCs and joint ventures are Philips, RCA, IBM, DEC, Sanyo, and Taiwan Semiconductor Manufacturing Company, a joint venture between Philips and the Taiwanese government. The best example we can find of government, universities and industry is the HSIP of Taiwan. This first science-based industrial park was established in Hsinchu because it is home of two major technical universities, National Chiatung University and National Tsinghua University, and several researches facilities including the ITRI. These two universities have provided HSIP with a steady source of highly trained manpower and have worked closely with the park administration and ITRI to organise various kinds of training courses and seminars of relevance to the firms. An additional contribution of the two universities to HSIP is the technology transfer function through research contracts, faculty consulting, and licensing/patenting. For example, an average of US$180,000 worth of research contract is awarded to Tsinghua University by firms in HSIP each year (Xue, 1997). Similarly, ITRI is an active player in R&D activities in HSIP through the 10 research laboratories and centres and more than 5000 highly skilled technical professionals. In fact, it is estimated that 80% of the firms in HSIP have various kinds of collaborations with ITRI and out of 99 firms created by Taiwanese capital in HSIP, 14 are ITRI spin-offs (ibid.) Moreover, other government national labs such as the Synchrotron Radiation Research Centre, Sub-Micron Device Research Laboratory, and National Super Computer Centre have contributed to improve the research environment by attracting more R&D support operations and other complementary research facilities to Hsinchu area.

In Taiwan IC (integrated circuits) industry is a very good example of how the partnership of government, the industry, and the universities and research institutions can make a great difference. In 1989 under the co-ordination of the Ministry of Economic Affairs, in order to facilitate the technology development process further, ITRI, major IC chip manufacturers and other companies in Taiwan formed a 'technology development alliance'. The aim was to develop 16M DRAM and 4M SRAM chip technology in five years time. The development plan called for an investment of US$ 192-231 million and over 200 engineers to work for the project. The venture is organised as a privately owned partnership and allows the company to be flexible and responsive to a dynamic market environment. The presence of the government serves to facilitate the start-up process and reduce the perceived risks by potential private investors. As a result, the IC industry has become the fastest growing industry in HSIP, which is still the home of all Taiwanese IC firms (ibid.).

Singapore as the home of many MNCs indirectly has a very extensive network through each of them. Moreover, the government of Singapore has consistently tried to exploit the location advantage of the country to establish world class transportation and materials handling facilities. In financial and other service domains it did establish a sophisticated communications and information technology infrastructure, and continued to upgrade the skills of its people to be able to quickly absorb new relevant technologies. All of these require extensive networking abilities. The government institutions and industry have to constantly work together. Since the mid 1980s, the government has established a number of research institutes and centres particularly in electronics, information technology and biotechnology in order to maintain a highly skilled manpower, develop pre-competitive technologies, provide services to companies, and transfer new technology to industry. For example, The IT2000 master plan was formulated after a rigorous study led by the National Computer Board in partnership with more than 200 senior executives from 11 major economic sectors of Singapore.

In Hong Kong, we find a good example of university-industry networking in Varitronix Company. In 1978 eight scientists and engineers, six of whom were from the Chinese University of Hong Kong formed the new company. Varitronix supplies customised liquid crystal displays (LCDs) and LCD-based electronic systems. Since incorporation the firm grew by about 20-30 per cent per year. By 1993 employment had risen to around 800 with - sales of more than US$45 million and client numbers in excess of 1,000. The company operated three manufacturing facilities located in Hong Kong, China, and Malaysia. Benefiting from US training and Hong Kong 's university facilities and faculty, Varitronix very quickly began to innovate with new products. The firm grew up with the LCD industry and kept abreast of the technology by investing in R&D, which was around 6-10 per cent of its annual turnover (Hobday, ibid. p. 181-3), But, given the non-interventionist government policy, this is more of an exception than a rule in Hong Kong in the development of new technologies. Nonetheless, Hong Kong has distinguished itself in its sophisticated financial institution networks, which has made it one of the big financial centres in the world.

India has made remarkable achievements in the fields of agricultural research, oceanography and biotechnology, nuclear and space technology. While in areas of hearth and industry, with some exceptions, did fail to live up to the early expectations that it would act as the main source of industrial technology for Indian industry. This is because during the two decades following the independence, India established a broad-based S&T infrastructure in education, research and supporting facilities. But no demands were placed on the S&T establishment to contribute directly to economic progress as all effort was directed to creating institutional and human assets (Hoffman, 1991). Industry development took place through import of technology and scientific research went forward under the spirit of free enquiry and was undisturbed by economic successes and failures. This is a kind of classical divide between the scientific activity and technological development. The two worked apart of each other with not strong linkages, which is reflected in the poor economic performance and lagging in international competitiveness of India compared to NIEs. Even the IRIs (industrial research institutions) has not made much difference and is largely considered ineffective. Universities, research institutes and industry is poorly linked. In other words, the national innovation system of India is not well integrated. There is an enormous potential if properly reorganised and managed, the component elements are all there.

In Brazil, the policies of import substitution, market reserves for local capital and the control of MNCs created an environment where the local private firms, state enterprises and MNCs could not freely interact and compete to form linkages and networks to improve the Brazilian industries vis a vis international competitors. The kind of linkages and networking typical of Brazil are those observed within the big public enterprises such as the Petrobras and Telebras, which have established a number of research and development centres. In general, universities, research institutions and industry are poorly linked and co-ordinated. But the liberalisation that started in 1986 is progressively changing that and leaner and fitter corporations capable to compete in the international arena are slowly emerging. This external competitive pressure will definitely push the Brazilian national innovation system to be more systematic and integrated.

Reaching a moving target requires a higher speed than that moving ahead. By the same token, catching-up by the developing countries requires a higher speed of learning, which may be considered an impossible objective. But since new technologies take time to mature, developing countries do have the opportunity of directly joining in the conventional technology, without passing through the previous technologies made obsolete by the present technologies, which by itself is a big jump forward. It is also the advantage of the late comer. It is very relevant to pose for a while to see the learning already achieved and the speed at which is happening. Below we will give examples of successful technological learning from each of the NIEs.

Let us start from Korea. Kim (1998 b) studied the organisational learning in an imitative catching-up environment of the developing country's point of view. His case is the Hyundai Motor Company. He shows that Hyundai had to pass four stages of learning: 1) assimilation of assembly operations, 2) development of 'Korean' car under license, 3) development of an advanced car under limited license, and 4) becoming independent. Kim shows us stage by stage how the company starting from acquisition of a production capability of Ford models (1968-1976); then, moved to the acquisition of engineering capability (1976-1992); and after that the company moved to the development of its own cars. Now it is doing serious research to break through in its 'green' car project (R&D based generation stage). It is competing on equal bases against the leading car manufacturers in the world. It is now the largest automobile producer in a developing country and thirteenth largest in the world. Kim believes that crises constructed proactively by top managers improved greatly the organisational learning of Hyundai.

Another example is that of Korean semiconductor industry virtually from scratch managed to leapfrog into the top ranks of dynamic random access memory DRAM) producers. Again, the top managers of the Korean companies exercised unique entrepreneurial leadership. Odd timing, time compression, and human-embodied technology transfer were essential elements of Korean entrepreneurs' highly spirited catch-up strategies (Dong-Sung Cho - Dong-Jae Kim - Dong Kee Rhee, 1998).

ACER of Taiwan gives us another example of fast learning and catching up. ACER started with 11 engineers in l976.By 1993 its sales had reached US$1.4 billion. Leading the local computer industry in the 1980s, ACER constantly strove for own-brand recognition abroad. In 1984, ACER developed its own version of 4 bit microcomputer followed by 8, 16, and 32 bit PCs; in 1986, it launched the world's second 32bitPC, after Compaq but ahead of IBM. In 1988 it began developing supercomputer technology using the UNIX operating system and in 1989 produced its own semiconductor ASIC to compete with IBM's PS/2 technology. In 1991 it formed a joint venture company with TI (and Taiwanese government) to make memory chips (DRAMs) in Taiwan and in 1992 formed alliances with Daimler Benz and Smith Corona to develop specialist microelectronics technology. In 1993 it produced a novel PC using a reduced instruction-set (RISC) chip running Microsoft's Windows NT operating system. It licensed its own US-patented ChipUp technology to Intel (in return for royalties); and received royalties from National Semiconductor, TI, Unisys, NEC and other companies for licensing out its PC chipset design (for further details see Hobday, 1995).

Singapore used education and training to increase its stock of human capital. These cheap and skilled labour coupled with the open policy it has given it a comparative advantage to attract the TNCs. By giving incentives, the government from 1970s onwards tried to attract more skill-intensive and higher value-added export industries. This led to Economic Development Board (EDB) organised apprenticeship and government-industry training centres with Japan, France and Germany. By 1991 the EDB operated five training institutes with an enrolment of 2,500 students: the French-Singapore Institute, the German-Singapore Institute, the Japanese-Singapore Institute, the Precision Engineering Institute and the Philips-Government Training Centre. These training institutes provided engineering, technology, and craft education for manufacturing industry. They provided also two and three year training courses in tool and 'die and precision machining, plastics-technology, factory automation, mechatronics and industrial electronics. Programmes of re-training and continuous education operated to support manufacturing industry as well. (Hobday, ibid. p.141). Besides, the National University of Singapore, Nanyang Technological university, the polytechnics and training institutes together supply a large highly skilled manpower, for example in 1991 they produced 22,000 engineers and technicians per annum which is about 38 per 100,000 population, one of highest levels in the world (ibid.).

In Singapore among the TNCs subsidiaries various forms of catching up learning occurred over time. These ranged from the production to innovation learning, from elementary to advanced learning and from technological to non-technological learning. As learning by assembly and testing became more complex, tasks involved more in-house, formalised training. Learning from foreign engineers and managers was widespread and senior foreigners continued to oversee some operations, assisting in the installation of new capital equipment and so on. NEC, for instance, employed 29 senior Japanese staff in its plant of around 700 employees (ibid.). One thing is clear though: Singapore depends mainly on the TNCs technologies in manufacturing. But it has showed great learning and innovation in the service sector particularly in the transport, communications and information services, which is based on the exploitation of opportunities offered by IT.

Hong Kong lagged behind the other tigers in technological capability. Most firms still focused on consumer electronics and the industry had yet to make a substantial transition to industrial systems. In 1990 Hong Kong electronics exports were only one-half of that of Singapore. R&D spending was low on average, the largest firms were smaller than their counterparts in Taiwan and electronics had yet to catch up clothing as the largest export sector (Hobday, ibid. p. 184). But Hong Kong has caught up as a world financial and trading centre.

The experience of a successful firm, Usiminas still producer of Brazil, shows that the best approach for developing countries is to reverse the usual sequence of developing technological capability, i.e. instead of innovation - investment - production, reverse it to production - investment - innovation (Dahlman, Bruce Ross-Larson, and Westphal, 1985). This is similar to the idea of L. Kim and Jinjoo Ire et al. 'acquisition-assimilation improvement or generation' we have discussed in chapter two. The firm was established in the late 1950s. The country had neither the technology nor the experience for setting up and operating such a plant. Entering a joint venture with a consortium of thirty Japanese steel makers and steel equipment suppliers was the option chosen in order to gain extensive experience in steel production. Local engineers were involved from the design, equipment selection, installation, construction, start-up, and operation of the plant but the Japanese did the engineering and project management for establishing the plant. After three years of technical training and production experience under the Japanese, the operational responsibility of the firm was transferred to the Brazilian engineers. As the plant's specialised personnel gained more understanding of steel production, they continued to make minor adaptations of the equipment to obtain the maximum performance from the initial plant. Eight years after the pant's start-up, a research centre was created in the firm. This centre gradually moved into applied product and process research some of which led to the development of new products and processes patented locally and abroad. When the time of expansion came, the local engineers did about a third of the engineering for the intermediate expansion and all the engineering for the next expansion was done more cheaply than it had relied on foreigners. After this, the firm became well established and it could scan the world technological frontier and draw up its own specifications for what it wanted to purchase and equipment was bought from suppliers in many countries. It started to manufacture capital goods for the steel industry in Brazil, and helped by providing engineering and technical assistance services for the design and installation of new steel firms in the country as well exporting technical services to neighbouring countries.

The present government of President Fernando Henrique Cardoso's anti-inflationary Real Plan of 1994 is pushing out the Brazilian firms into open. Many of them have learned the lesson. We have examples, in Sadia Concordia a food processing giant that had to lay off 5,000 workers and automate poultry processing and packaging, a $100 million project, and the result is that output per employee has increased by 25% and fixed costs are down 11% (Business Week, June 30, 1997). Textile and footwear makers are also fighting back the cheap Asian imports. Sneaker manufacturer Cambuci, for example, saw its sales drop from $199 million in 1995 to $164 million in 1996. But at the end of 1996 have reduced labour by one third and moved their production plant from Sao Paulo state to Northeast Brazil, where labour cost are 20% lower and tax breaks are attractive. Similarly, T-shirt maker Wentex Textile is spending $140 million to complete 'one of the world's most advanced integrated knitting facilities' in the Northeast Brazil. It is undercutting Chinese imports with T-shirt selling for just $0.75 (Business Week, ibid.). Plane manufacturer Embraer, privatised in December 1994, focused on logistics to cut by nearly half the time it takes to build some aircraft. In mid-June 1997, it announced contracts totalling more than $I billion to supply versions of its EMB-145 commuter jet to subsidiaries of American airlines Inc. and continental Airlines Inc. (Business Week, ibid.).

India's learning for greater international competitiveness outside the software market is negligible. But India's ability to create world class Institutes of Technology is worth mentioning as an example of how developing countries can match the first world's much admired higher learning institutions. The stars of Indian Institutes of Technology are IIT-Delhi (physics and mechanical engineering), IIT-Kanpur (computer science), IIT-Guwatrati (First grads in 1999), IIT-Bombay (chemical engineering), IIT-Kharagpur (geophysics and rocket science), and IIT-Madras (computer science).

India has created, out of limited resources, a class of executives and entrepreneurs who manage to combine technical brilliance with great management skills. And the Indian government has not tried to keep these first-class students at home. In many ways, the IIT grad is the hottest export India has ever produced (see Business Week, December 7, 1998). This shows how big the Indian brain drain problem is. Nonetheless, India has emerged as a serious contender in the international market of computer software, in particular the labour intensive lower end of custom-made programming services.

Every country in the world invests in S&T in the hope of improving the socio-economic problems of their people, more so for the developing countries. These countries cannot afford to invest in S&T their scarce resources for the sake of pure knowledge. Therefore, they need to measure their S&T efforts in terms of concrete results. One of such crude measure or indicator of achievement is the improved international competitiveness. This is what we are trying to do next.

Just 15 years ago, Korea had no substantial position in the electronics industry. By the early 1990s three of the local Chaebols ranked among the largest electronics producers in the world: Samsung Electronics, Goldstar Co. Ltd., and Daewoo Electronics. For example in 1992, Samsung's electronics operations sales were larger than most European and US firms except for IBM. Even though it was only a quarter of the size of Sony of Japan, its profits were almost half that of Sony. Anam Industrial is the largest chip packaging company in the world. It exported about US$1.8 billion in 1992. As a result of the strategies of the Chaebols and other fast growing local companies, production and exports of electronics outstripped steel, automobiles and most of other industries by a wide margin during the 1980s (Hobday, 1995).

The effects on the economy of Taiwanese government effort to inject scientific and technical resources into the development of new technology can be seen in the rapid growth of the export value of technology-intensive electronic and information products. This has surpassed that of labour-intensive textile products and garments to become the largest single industry by 1987. The export value of electronic and information products increased from US$3.1 billion in 1981 to US$ 12.5 billion in 1989, as against that of textile products and garments, which increased from US$ 4.8 billion to US$10.3 billion over the same period. This rapid development of electronic and information industries has had repercussions on many aspects of the economy. It has not only raised the productivity of all domestic industries but also affected the mode of life and work and, finally, the direction of science and technology development (Liu, ibid.)

Manufacturing in Singapore grew from around 18 per cent of GDP in 1960 to 27 per cent in 1991, accounting more than 50 per cent of the country's foreign earnings. Within manufacturing, electronics was the largest sector in 1991, accounting 34 per cent of gross manufacturing value-added, which increased to 40 per cent in 1992. After electronics, the next sector was chemicals and chemical products. The bulk of electronics production was carried by the large TNCs for export. The industry employed 124,000 people in 1991. A small number of local firms grew to become medium-sized TNCs in their own right, including Singapore Technologies Industrial Corporation, Wearnes Technology (the big two), PCI Inc., Eltech Electronics and Goh Electronics. A combined sales of the top five was about US$0.7 billion in 1989 which is a small amount compared to that of the TNCs.

Hong Kong has been able to build up a significant position in the world electronics industry relying on a mixture of foreign TNCs and small indigenous local firms. By 1990 the city exported in the region of US$7.5 billion worth of electronics products (Fok, 1991, p.257). But in its technological capability is behind the other three tigers.

India did lag behind the NIEs of Southeast Asia in the international competitiveness with the exception of the software market, which is increasingly recognised as world player. Indian engineers are among the best in the world in meeting complex programming needs Wall Street Journal, 6 January 1993). Many Indian companies have been awarded the ISO 9000 quality certificate and Motorola's Indian subsidiary is one of only two units world-wide to receive the Software Engineering Institute's Level 5 rating on their Capability Maturity Model. It is estimated that India also has about 11%o of the $5 billion global software outsourcing market (Asia Week 25 October 1996). With its 250 high-tech firms, including home-grown multinational software and networking giants Infosys and Wipro and other hundred software firms on the outskirts of the town, Bangalore is the Silicon Valley city of India (Newsweek, November 9, 1998).

In Brazil, the technology policy regime has been characterised by objectives other than the acquisition of technological capabilities that would allow firms to become internationally competitive. Government interventions were designed to enable domestic firms to operate in new areas, design import substitutes with their own or acquired means, achieve a measure of technological 'autonomy', and displace multinational firms from certain key industrial segments (Dahlman and Frischtak, 1993). As a result, the country has failed to attract best practice technology via direct foreign investment or through arms length transactions. A combination of weak domestic technological efforts and restrictive access to the most valuable foreign technology appears to have hampered the modernisation effort of Brazilian firms.

5

5. Information Technology in NIEs

5.1 Introduction

In the previous chapter, we discussed S&T in relation to the economic development of the NIEs. In this chapter, we will focus on IT and its significance to the economy of the NIEs, in particular that of Singapore, India, and Brazil. This will allow us to deal in greater depth with each of them. These countries have exerted a lot of effort and money to master information technology with the aim of specifically "leapfrogging". It is a very rich experience, which is a clear message of the possibility of catching up in this new and pervasive technology.

5.2 Environmental context

Singapore, India and Brazil have joined the IT international market. The environment in which they have to compete is the same international market where competition is against the advanced countries. Therefore, it is relevant to start from a brief assessment of IT industry in general.

One technology with potential for stimulating economic growth and productivity is information technology (Kraemer and Dedrick (1994). Some researchers make a specific argument for the value of investment in IT as a stimulus for economic development. These arguments for IT-led development are based on the notion that investments on IT can accelerate economic growth by enhancing worker productivity and increasing returns to - investment in other capital goods (APO, 1990; Mody and Dahlman, 1992; OECD, 1988, 1993; Rahim and Pennings,1987). Brazil and Singapore have particularly singled out IT as the technology of the future and have heavily invested in it. India is also participating in it, particularly in the software market. Each of these countries is following a path of its own.

IT is seen as a generic technology, such as semiconductors, computer systems and software, which are pervasive in their impacts on industrial and economic development. Unlike a new technology for steel or chemical production, IT can be applied in virtually every economic sector, from automobiles to insurance. Its application can make production more efficient, enhance existing products and create new products and services. II can reduce the cost to business by obtaining and processing information on markets, suppliers and competition, thus improving organisational efficiency and responsiveness. In addition, the IT industry itself can be a source of economic growth and jobs. For these reasons, investment in IT is believed to enhance national productivity and competitiveness, spurring economic growth. Several studies (Mody and Dahlman, 1992; Rahim and Pennings, 1987) suggest that IT development may have led or anticipated economic growth in the East Asian NIEs, particularly that of Singapore.

Such conclusion runs contrary to empirical research about the "productivity paradox" (Baily, 1986; Baily and Gordon, 1988; Loveman, 1988; Roach, 1987 and 1988). Many have concluded that productivity gains in the aggregate economy from IT use have been limited, despite the rapid improvement in price-performance ratio of computers and heavy investments in IT. This argument is based on the fact that the United States invested heavily in IT during the 1970s and 1980s, yet productivity growth slowed during that period compared to the earlier post-war years (Baily, 1986). Investments in IT have been large. IT often accounts for a quarter or more of a firm's capital stock (Roach, 1988), and accounted for 48% of all new private investment in equipment in 1988 and the proportion is still climbing (Attewell, 1991). IT investment in the service sector grew tremendously relative to IT investment in manufacturing, with 84% of the nation's muITi-billion dollar IT investment going into services. Productivity in manufacturing, however, increased during this period while productivity in the service sector remained stagnant. At the firm level some studies in output related to levels of investment in IT, in the manufacturing sector, found the productivity gains from IT to be insignificant (Loveman, 1988).

The productivity paradox does not deny the possibility of productivity improvements from the use of IT. On the contrary, those authors who have written most about the paradox tend to stress the enormous potential gains. The efficient implementation of II is often hampered by many social and organisational barriers. Researchers have offered a variety of explanations for why the expected payoffs might not show up. The explanations fall into four broad groups: measurement errors, time lag for diffusion, management of IT, and redistribution (Attewell, 1991; Brynjoffsson, 1993). The first three explanations suggest that we need better data, a longer time frame and better technology management to identify productivity gains from IT investment. The fourth suggest that IT investments will not increase output, but only redistribute it. In a global economy, however, nations could benefit from IT investment just by making their firms more competitive against foreign firms.

Roach (1987, 1992) had already said that with the exception of the telecommunication sector measured productivity gains have not substantially accelerated in the period 1960-1990 despite rapidly increasing investments in computers and other types of information technology. Newer studies attempt to deal with measurement errors and time lags by using larger samples over longer time frames. Such research has been finding evidence of significant payoffs from IT investment at the firm level (Brynjoffsson and Hitt, 1993; Lichtenberg, 1993). In particular studies with much larger and more recent data sets have found positive returns to investments in information technology capital and labour Brynjoffsson and Hitt (1994a, 1994b). Their results were robust with respect to different specifications of their production function, and have been replicated by Lichtenberg (1995). But there are people who still dismiss the computer productivity by saying that they provide only features without real value and make possible an increase in the scale of operations without improving economic productivity (Landauer, I 995).

Studies of returns from II investment at the national level tried to measure relationships between IT investment and output by comparing data across countries over time, rather than relying on comparisons of data on only one country at different time periods. These findings provide preliminary evidence to challenge the notion of the productivity paradox (Kraemer and Dedrick, 1994). IT investment, especially in conjunction with investments in supporting infrastructure, has a positive impact on productivity and economic growth. But one thing is very clear IT requires a whole new social and economic structure to show its full productivity potential. Piece meal changes of replacing old methods within the old paradigm of organisation and management systems with the new technology won't bring the real revolution. New enterprises moulded by the new vision brought by the new paradigm of the microelectronics revolution will be required. 'Automating' is part of the old paradigm and we need to change to 'informating'. Many pioneer firms are already showing the right path.

If is very important at this point to distinguish the many facets of IT. Broadly, we can have three major areas: the hardware industry, the software industry, and the infrastructure. Today, all countries are users of IT in greater or lesser degree. But not all are producers of these s technologies. Developing countries fall among the users with the exception of NIEs that are joining now the big league in the supply of these technologies. When we use IT to enhance the productivity of other industries, then, we are using it as an infrastructure. Regardless of density, we have information and communications infrastructures in all countries. It is, therefore, very important to address the question facing policy makers of whether there is more value in developing_ an IT industry or in applying IT to other sectors of the economy, and whether promotion of one will be detrimental to the other.

The benefits of IT use is great and the cost of policies which would depress demand for IT is high (Kraemer and Dedrick,1994). The use of IT can offer greater economic benefits than the production of IT (Flamm, 1987). But the presence of sophisticated users is vital to developing production of IT, both to provide a market and to provide for the close interaction between producers and users that stimulates innovation and improvement (Schware, 1992). These points of view argue for policies favouring use, and if production is to be promoted, that it be done without trade barriers or other policy instruments, which protect domestic producers but discourage investment in use by increasing the cost of IT products.

Software industry constitutes the fastest growing segment of the information technology market. With world sales exceeding US$ 100 billion annually, the software sector is targeted by hardware suppliers and specialised software firms alike. Though largely dominated by enterprises from the industrialised countries, software is still regarded as an opportunity in many developing countries (Correa, 1996). Software is both "embodied" when put into operation in a computer system, and "disembodied' when commercialised as a product. Given that software is skill-intensive and developing countries have a lower wage advantage, there is a possibility for them to become internationally competitive. Besides, it does not require huge investments as IT production. There are a number of reasons why the software industry is attractive for the developing countries (Correa, ibid.):

1. Software development is skill-intensive.
2. The technology for software development is largely available at universities and research institutions.
3. Despite the high degree of normalisation of knowledge involved in software development, considerable room is left for creativity and ingenuity, and for tacit knowledge based upon experience. Software development is often described as still being an "amateurship, craft-base discipline', (Cane, 1992, p. 172).
4. The components of technological packages applied may significantly vary in accordance with the products. Time and investment necessary to develop systems software are also generally higher than for application software.
5. Though the use of quality standards is growing, at least in industrialised countries, quality controls and methodologies may greatly vary, affecting the quality of the final product. It is to be presumed that the implementation and diffusion of quality standards increases barriers to entry, and that the management of quality issues is likely to become a key competitive factor in the software field. The implementation, in particular, of the ISO 9000 standard is viewed as a necessary step to compete in a global market.
6. Like in capital goods industry, software may be produced to meet a particular client's demand ("custom") or as a standardised product ('package"). Most software firms in Latin America and India produce primarily "custom" software.
7. An understanding of users' requirements is essential for software creation. It is of particular importance to devise strategies that are as far as possible try to incorporate users in the early creation/production of software. Developers that face unsophisticated users are unlikely to build up capabilities to compete in the international market.

8. The rapid pace of technological change and short life-cycle of products force software companies to undertake research and development (R&D) and to invest in training for new technologies. The rate of failure in this sector is high.

To give a brief analysis of the above listed reasons, the first three are suggesting that the technology for software development is already available at universities and research institutes since it is based on the skills and the creativity and experience of people in these institutions. The fact that it does not require capital investments such as in the microelectronics production, barrier to entry is low. Application software requires less time and investment to develop than the systems software, therefore, easier to join by developing countries. Quality factors alone can increase the barrier to entry and developing countries need to build based on the culture of quality, if they are really going to make a breakthrough in this market. It is easier to enter the 'custom' software market before entering the 'packaged' software for the latter require greater investment to meet quality and reliability standards. One of the greatest challenges to developing countries when entering the software market is the non-availability of sophisticated users in their home market or the few sophisticated users might look outside for reasons of quality and reliability. Involving as partners these sophisticated users in the production of software would be the easiest way out. For example, the Brazilian banks did it. Finally, the rapid technological change in software market is both a threat and an opportunity. It is a threat because if you do not undertake R&D you may become quickly irrelevant. It is an opportunity because the chance is open to creative entrepreneurs, which may be the new comer. But software exports from developing countries face a number of obstacles which some are internal and others external. The internal constraints are things like the lack of sufficiently large domestic market to provide a platform for complex products; the small size of the software firms and lack of financial resources and support; lack of stringent quality standards; the cost of management, administration and marketing is very significant; lack of highly qualified and experienced people; lack of appropriate infrastructure relevant to the development of software industry such as telecommunications and standardisation; and the lack of international marketing and distribution networks.

Domestic markets in developing countries are very small. Even India and Brazil do not have sufficiently large market for complex products. For example, Indian software market depends on the US market and this is mainly routine the of labour intensive kind of programming works. Of course, it is a stepping stone to the next phase of entering more complex and demanding markets. But developing countries need to do more in providing financial support to creative entrepreneurs, help them upgrade their quality standards, minimise the brain drain problems, encourage partnership with international firms to gain marketing and distribution networks access, and providing them with appropriate infrastructure.

In addition to internal constraints, there are a number of limitations emerging from the structures of the software supply and of the international market. The software market, probably the fastest growing market in the realm of information technologies, is highly competitive and internationalised. US firms control the largest part of the world market and have preserved an uncontested leadership in operating systems and packaged software. According to International Data Corporation (IDC) estimates, the United States holds about three-quarters of the world software market, compared with 20% of Europe and 4.3% of Japan (Fortune, 1994, p.48). The market is concentrated both at the high end of software products (dominated by IBM) and at the low end. Thus, around 60% of the market for PC software is accounted for by 10 firms and 45% by four firms, among which Microsoft holds a dominant position. Software supply is divided between specialised software houses and computer manufacturers, competing in operating systems and application software and services. The top software vendors include both the former and the latter. Software packages are the main driving force of the market with a tangible trend toward an increasing sophistication and integration of products and the development of vertical markets. And the packaged software represents the largest proportion of traded software.

Developing countries cannot head on compete with the advanced countries. Given the trends in globalisation, there are opportunities to gain access in areas where wage advantages are in favour of the developing countries. Having productive and skilled people by itself is the greatest competitive weapon and developing countries can use it to develop advantageous partnership with advanced countries.

Therefore, it is within the above complex situation that the developing countries have to find a path that can lead them to join the world market and get a fair share of it. They can staff from the use of already tested information technologies to improve their productivity in every sector. The other is to carefully assess all opportunities in the progressive development of information technology industries particularly the software industry.

When it comes to the hardware industry, developing countries have a long way to go. This is an industry not only driven by S&T at the technological frontier but also it requires a huge investment and large R&D capability, which is not readily available in the developing countries. In the next sections, we will learn a lot from the NIEs with this regard.

5.3 IT Policy

The first question we need to ask is whether NIEs have consciously or deliberately chosen particular strategies to introduce, diffuse, and master information technology in their respective countries; or it is something, which is evolving spontaneously without the intervention of governments. If so, which market forces are responsible for such developments? It is also possible to put the same question this other way round: What roles the governments and the market forces play in the development of information technology in such countries as Singapore, Brazil, India? We will explore the experiences of these countries and get an answer in the following sections.

Recent trends in countries such as Brazil and India have been to remote restrictions on imports; technology transfer and foreign investment in order to gain access to low-cost IT products and advanced technologies. Such a trend seems an acknowledgement that previous policies to promote production were too costly to user industries in those countries. Countries which have been successful in IT production, such as Singapore, Taiwan and Korea have succeeded largely through attracting multinational computer companies to invest in production facilities or subcontract with local firms. Of these three countries, only Korea has used protectionism from 1982 to 1987 as a tool for promoting IT production, and Korea only did so for a limited period, banning imports of microcomputers (Kraemer and Dedrick, 1994).

The importance of acquiring and applying microelectronics technology for national development paths and particularly industrialisation prospects has been recognised, by statement and action, by all the Governments of the countries studied.

Even though we want to learn from all, Singapore merits a special attention for a number of reasons. First, Singapore is a small country like Eritrea- Population of Singapore is about 3 million people and that of Eritrea is 3.5 million. Singapore is a port-city-state and Eritrea is a country with km 1200 coastline and about 300 small islands all uninhabited but the big two. In the case of Eritrea, its territory is big compared to that of Singapore but the industrial zone is concentrated in a radius of about 100 km. around Asmara, the capital city of Eritrea. For that matter, Singapore industrial zone extends way beyond its territory into Malaysia and Indonesia in the "Johor-Singapore-Riau" Triangle, which is about 100x200 km. in size. The economy of Singapore is heavily dependent on trade and it is one of the trade centres and service-hubs in the Southeast Asian region. Eritrea in its Macro Policy (1994) is betting on trade and becoming a service-hub in the Red Sea and East African region. These are the best of similarities that we can make of the two countries.

The environment of these two countries is different. The social and cultural structures are also different. Now Singapore is in the middle of Southeast Asian countries, all booming economies. Eritrea is in the horn of Africa, which is a very unstable political environment. But at the same time is very near to the oil rich countries of the Arabian Peninsula and the Middle East. It is also not far away from the big European market. It is possible to say that it is half way through Europe and the Far East. Massawa and Assab, the two port city of Eritrea are found in the middle of the Red Sea. Eritrea, therefore, has a great potential to become a transiting and service centre in this important route of trade.

Beside all the facts we have raised above, there is another thing worth mentioning. The Eritrean leadership is increasing looking to Singapore as a model of development. There was a lot of debate going on why and how Eritrea can successfully follow the steps of Singapore. In the view of the Eritrean leadership, all the factors that are said to be the reason for the success of Singapore are present in Eritrea. The major factors are a strong leadership, a clear strategy, stable government and peace (now afflicted by the border conflict with Ethiopia), hard working people, entrepreneurship, and an open market economic system. If we want for evidences that show the Eritrean leadership is serious about what it is saying, we can look to the visits many top Eritrean officials are paying to Singapore. Recently the Eritrean president paid a three-day visit to Singapore on April 8,1997 and it is reported that Singapore is to help Eritrea modernise its port of Massawa. "My government intends to enhance and upgrade our bilateral relations," Isayas Afewerki, the president of Eritrea said later at a dinner. "Your visit to Singapore has given a boost to bilateral relations," Goh said in reply. "Let us work together to advance our common interests" (Reuters, April 9, 1997). Therefore, there is more reason to believe that Singapore stands out as a model more than the other two, Brazil and India. Nonetheless, it is possible to enrich the learning from these other two as well. Whichever country is taken as a model, it is not possible to have a carbon copy of it, nor it is desirable. Therefore, we have chosen to include the other two to have a broader view.

This section is organised around three key concepts: the vision and objectives, the policies, and the management and result of the information technology in the said countries.

5.3.1 Vision and objectives

5.3.1.1 Singapore

Singapore's vision is to transform itself into an intelligent island. This vision has been formally established in its IT 2000 master plan of 1991. The National Computer Board (NCB) prepared this master plan in partnership with more than 200 senior executives from 11 major economic sectors of Singapore. These are Construction and Real Estate, Education and Training, Financial Services, Government, Healthcare, IT Industry, Manufacturing, Media, Publishing and Information Services, Retail, Wholesale and Distribution, Tourist and Leisure Services, and Transportation. The major Gaols of the IT 2000 are to develop Singapore into a global hub; boost the economic engine; enhance the potential of individuals; link communities locally and globally; and improve quality of life.

All of this is prepared with the specific mission to drive Singapore to excel in the information age by exploiting IT extensively to enhance its economic competitiveness and quality of life. This bold step being taken by Singapore is to some extent linked to the results it got to the -efforts put in during the 1980s to single out information technology as a strategic move towards a technology driven economy. Singapore's policy on IT was initiated in 1980 when a ministerial committee, the Committee on National Computerisation (CNC), was formed to spearhead a new national strategic thrust based on IT (Wong Seng Hon, 1992). A new government agency, the NCB (National Computer Board), was established in 1981 to be the executive agency to accomplish three objectives set by the CNC: (i) to computerise the ministries and departments in the civil service to improve productivity and to "bootstrap" computerisation in the entire country; (ii) to train 8,000 software professionals by 1990 to meet the anticipated needs of the nation; and (iii) to encourage and support the expansion of the indigenous computer software and services industry.

The twin objectives of the National IT Plan were to improve productivity and competitiveness in every sector of the economy, and to develop a strong export-oriented IT industry. Although the socio-political implications had been in the minds of the Singapore policy makers, nonetheless, these were not emphasised because of the predominantly economic concerns that have motivated the formulation of the National IT Plan. The country has been able to achieve satisfactorily these objectives. Now the country is coming close to achieving a new record, being the first country in the world with an advanced nation-wide information infrastructure which will allow computers in any parts of the country to be interconnected both to one another and to other computers located anywhere in the world.

5.3.1.2 Brazil

We don't find a vision driven development of information technology in Brazil like the one seen in Singapore. The reserve market concept was launched in 1975, at a time when nationalist feelings were high and science and technology were linked to military power and economic strength, and the import substitution models were popular in Latin America. It was simply based on the classical import-substitution model. It is possible to say that its major objectives were to create national capability in information technology, thus reduce technological dependence; to use information technology as an infrastructure to strengthen the national economy; and to achieve international competitiveness in the information technology industry.

During the 1980s, because of the macroeconomics imbalances and economic austerity measures that followed, the electronics industry suffered, as a result, financial drought. The industry was diversified but fragmented. It could not emerge as a serious international contender like what we have witnessed in the Southeast Asian NIEs. Most probably, the lack of vision and focus has also harmed the industry together with other macroeconomics problems the country still up to now is suffering.

5.3.1.3 India

In early 1970s the Indian State established two permanent bodies, a policy making body (the Electronics Commission) and an executive body (the Department of Electronics). The underlying strategy for electronics, as in the case of other key industries, was to achieve an import-substituting, self-reliant, public-sector led growth with very little role for monopoly houses and foreign companies. But in 1981 the 'New Economic Policy' a series of relatively liberal policies began to be introduced. The new policy measures emphasised the need to create an economically viable capacity to ensure international competitiveness (Joseph, 1992). Therefore, we can say that there is lack of a clear vision for the electronics industry but at the same time, reading from the general scientific and technological development trend of the country, the following objectives have been always there: to catch up in electronics R&D; to be self-sufficient for reasons of import-substitution; to promote the diffusion of computer systems, and (lately with the new liberalisation); and to innovate for greater competitiveness in local and foreign markets.

Information Technology has a huge potential both to India and Brazil. Hanna and Boyson (1993) say that IT development could play four major roles in support of India's development strategy, which could be applied to other developing countries as well. It could, for example, enhance exports, particularly software exports - by facilitating logistics, increasing the productivity, quality, and flexibility of manufacturing, modernising the transport and telecommunication infrastructure, and attracting foreign investment. India's new policies for trade and industry make information and communication services a key need for both business and government. It could promote private sector development -- by modernising financial services, mobilising and disseminating public information, reducing information failures and transaction costs, improving access to legal and regulatory information and to industrial standards information, creating a dynamic IT industry, and modernising services and management systems. It could improve public sector management - by facilitating coordination and decentralisation, modernising information and communication systems, improving databases for policy analysis and monitoring systems, improving the planning and monitoring of public expenditure, introducing managerial innovations and decision support systems, and modernising large transaction systems, such as tax administration, land records, and the treasury. It could also alleviate poverty and accelerating learning and. Human resources development - perhaps by reducing the pervasive forms of information poverty, (Communication, Participation and Democracy, Society for International Development, l99O:2, and World Bank, l99l) improving the management and monitoring of poverty alleviation programs, improving agricuITural extension, improving learning in and out of schools, and extending hearth and educational services to remote and under-served areas.

All developing countries, the NIEs in particular, are struggling to join the club of the developed countries. Increasingly the sign of economy maturity is measured by the degree of science and technology mastery and technological independence. This mastery and independence is measured by your international competitiveness. Therefore, the basic objective of information technology cannot be else than "catching up" and be part of the big league.

5.3.2 Information technology policy

In this section we continue to discuss of Singapore, Brazil and India separately to keep distinct the unique experiences that each country has had in the process of creating and developing IT industry and compete at the international markets. Without repeating what we have already discussed in the previous chapter, we will keep basically the same structure. Particularly when discussing IT management, we will deal with organisation, networking, learning, and competitiveness. In the previous chapter, we dealt with S&T policies in relation to economic policies, how the resources in those countries were organised and integrated, how learning was managed, and the competitiveness achieved. Similarly now, in more -focused manner, we will see how IT is organised and integrated into the economy, the industry networking, the learning and competitiveness achieved in the international markets.

5.3.2.1 Singapore

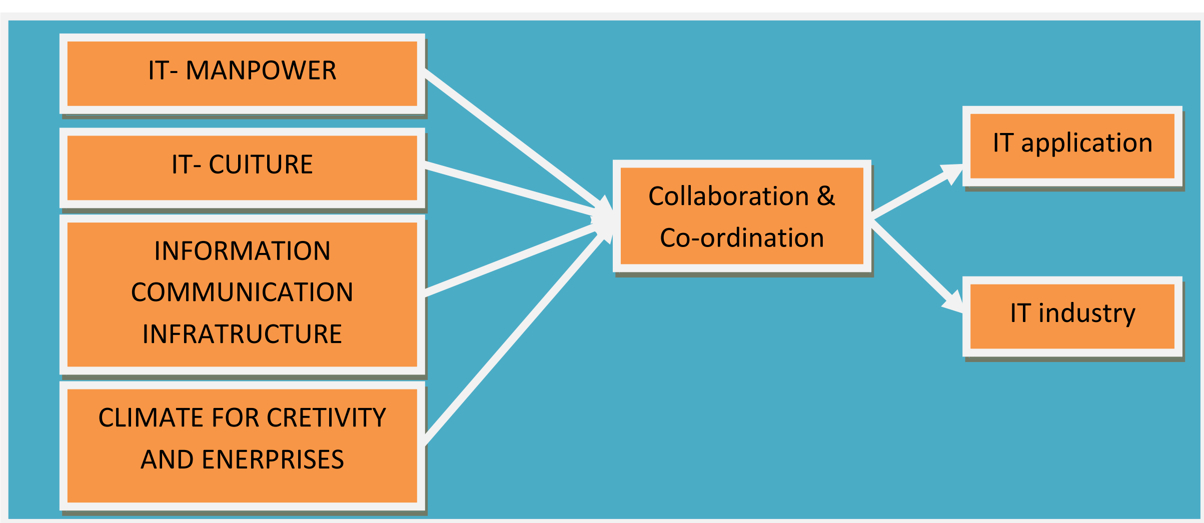
The increasing 'informatisation' of the global economy was a trend noted by the Singapore government in the early 1980s. IT, in particular software, was identified as the key enabling technology in the informatisation of the economy, and a technology particularly well suited for Singaporeans to excel in. It was deemed to have a significant role in restructuring of the economy toward higher value-adding activities, and the IT industry was itself regarded as an active niche for Singapore to develop (Wong Seng Hon, 1992).

The Economic Development Board (EDB), the National University of Singapore, Singapore Telecom and National Computer Board (NBE), in 1986, collaborated in the formulation of a new national IT strategic framework for Singapore - the National IT Plan (NITP). This pioneering multi-agency planning effort was motivated by the confluence of three independent developments. All three segments of the information industry telecommunication services, hardware manufacturing and software development – have undergone rapid growth. It was, therefore, timely to integrate government supported programs aimed at these different segments so as to drive new synergy. IT was increasingly seen as a key productivity tool in the restructuring of the economy. It became necessary to promote more linkages between the IT strategies and the economic development strategies. And the economic slowdown in 1985-86 started a search for new ways to sharpen Singapore's competitiveness in the global economic system. IT was seen as an important contributor to the generation of new competitive advantages for the nation (Wong Seng Hon, 1992).

A strategic framework, consisting of seven interlocking building blocks was formulated to encapsulate the strategies of the NITP. This framework is depicted in Figure I. The key strategic thrust was the following (ibid.):

- IT application: leverage on the Civil Service Computerisation Program, the creation of new national information infrastructure, and a sector approach to induce organisations to exploit IT.
- IT manpower: collaborate with the global technology leaders to develop a vital software engineering capability.
- IT industry.' nurture a vibrant IT industry, with global orientation, by encouraging the participation of multinational IT companies and innovation by local IT companies.
- IT culture.' engender a positive attitude toward IT among the population through an annual IT week and widely available educational programs.
- Climate for creativity and. enterprise,' establish IT innovation centres within government agencies and educational institutions.
- Information communication infrastructure: build national information structure based on the latest tested technology and provide services at globally competitive prices.
- Co-ordination and collaboration' network across agencies in the public and private sectors, with the NIP as the common strategic framework and the NCB as the spearheading and co-ordinating agency. [Won Seng Hon (1992)].

Figure 5.1: IT strategic framework for Singapore



As the government is keen to seize opportunities effectively and quickly, it has pushed and pulled the private sector into the IT age, especially the smaller and the medium-sized local companies, along with the MNCs.

The NCB is charged under its IT2000 project to identify strategic IT applications across each industry sector 'in Singapore, and it works closely with the EDB which is the key agency in investment promotion. The thrusts of IT2000 are in application-driven R&D, globalisation, supportive business infrastructure, communication and co-ordination infrastructure, and intensified manpower development. Clearly, Singapore aims to intensify its role as an information centre for its own competitiveness as well as linking it with development in both the region and the rest of the world. This IT focus is complemented and supplemented by other physical infrastructures as in the notion of an international transport and telecommunications centre - the concept of hubs and tele-ports. If done properly, Singapore can be a growth pole for the region using IT as the medium. If IT 2000 succeeds, Singapore will be transformed into an "intelligent" island city and will strengthen its competitive edge among nations as well as enhancing the quality of life of Singaporeans (Heng and Low, 1993).

Many other agencies are also collaborating with the NCB to implement various IT programmes. Apart from MNCs and local enterprises, which are developing expertise, hardware and software products, the Civil Service Computerisation Programme has been extended to the private sector to evolve nation-wide information systems. National electronic data interchange (EDD networks include TradeNet, Medinet, Buildnet, Lawnet, among others. Thus, trade documentation has been greatly simplified and expedited in time just as the stock market has gone scriptless. The Small Enterprise Computerisation Programme helps smaller firms to join the IT age. The 'smart card' offers a new business opportunity on nation-wide, multi-service, and multi-functional bases, which can be used for making purchases or assessing other financial services. Telecommuting would similarly become increasingly - feasible, and expert systems will change the way that banks service their customers. A wide array of IT training institutions is developing specialists in communications, integrated manufacturing, artificial intelligence and software engineering, as found in other new industrial and knowledge economies (ibid.).

With effect from January 1991, the National Science and Technology Board (NSTB) have taken over from the Science council the task of promoting science and technology. There is greater focus on R&D under the new National Technology Plan (NTP) released in 1991.

Singapore's continued importance and survival in the region, its leadership thinks, will greatly depend on how it can act as a technological node in assisting economies in the region to be 'informitised' and integrated into the new global production system. While competition is a means of ensuring efficiency, there is also a parallel need to collaborate and co-ordinate efforts in reaping the benefits of IT. At present, Singapore is clearly ahead of many of its ASEAN neighbours in the IT game. While others are seeking to become 'intelligent' states, Singapore's strategy is to try always to be a step ahead to reap the benefits as first comer.

5.3.2.2 Brazil

The core piece of the Brazilian experience in 'Informatics Policy' is the market reserve for national producers in a number of sub-sectors of the electronics complex. Thus it is classical case of infant-industry protection except that not only imports are kept out through quantitative controls but also foreign firms are not allowed to produce behind the protective barrier, the nationalist concerns and influence at its high.

Until the late 1970s, Brazil's computer industry was in the hands of foreign firms which either imported finished products or carried out the final assembly of goods locally. By late 1980s, this situation had changed almost out of all recognition. By 1986, the number of firms operating in the nationally owned computer and peripherals market increased to 310 from four in 1977. Employment in these firms grew from just 4,000 in 1979 to over 50,000 in 1988. Total sales of national firms in 1988 were in the region of US$3,000 million, accounting for 66 per cent of the computer market (Schmitz and Hewitt, 1992).

This rapid growth resulted from the creation of a reserved market. Foreign corporations were not excluded from the Brazilian computer market. Rather, they were limited to specific market segments. The mini- and microcomputers were reserved for the Brazilian private capital. This policy is carried out by the Special Secretariat for Informatics (SEI) which is specialised government agency working under the Ministry (later Secretariat) for science and technology. The main policy instruments used by SEI are quantitative import restrictions and the concession of manufacturing licences to national firms. Foreign firms are limited to the production of mainframe computers. They are also controlled by SEI to the extent that the granting and withholding of import licences can force these firms to have increasing indices of nationally produced inputs in their final products and also to show positive export balances (Piragibe, 1985).

These policies have their origin in the Commission for the Co-ordination of Electronic Processing Activities (CAPRE) which was created 1n 1972 and had a regulatory role over information technology. Control over computer imports began in 19'15, at which time a number of complementary policy measures were also set in motion (Piragibe 1985, Tigre 1983). The beginning of the market reserve dates from 1977, when the production of minicomputers was put to tender for national firms (Frischtak 1986).

In 1979, CAPRE was transformed into SEI with a wider mandate. The protected market for national firms under SEI's guidance gradually spread to other areas, such as industrial automation equipment, micro-electronic components, digital instruments, superminicomputers and others. In 1984, the market reserve and complementary measures were enshrined in the 'Informatics law' (Meyer-Stamer, 1988). In practice, policy decisions rarely result from rational evaluation but from political and economic pressure. The IT policy is not an exception. In fact, Brazil's IT policy has been one of the most severely contested cases of recent industrial policy (Bastos, 1992). The policy was politically viable in spite of growing hostile forces. These included the US government threat to Brazil of trade war. Such pressures eroded the supportive internal alliance, but did not lead to a dismantling of the policy in the 1980s. Compromises were made but the policy essentially remained intact. Some link this achievement to the build-up of a negotiating capacity in government. It is possible to go a step further and argue that the heavy critique of the policy contributed to the learning, which occurred in both industry and government (Schmitz and Hewitt, 1992; and Cassiolato, Hewitt and Schmitz, 1992).

In the case of the Brazilian electronics industry only the simple comparison of domestic and international prices has been carried out and has led neo-liberals to dismiss the infant-industry argument as a failure (Cline 1987). In spite of rapid cost reductions the prices of microcomputers, printers and digital control systems are approximately double the world market levels. However, in countries without import restrictions users also pay well above world market prices and the non-protected sub-sectors of the Brazilian electronic industry (in which foreign firms dominate) produce at above world market prices. Whether it is or not depends on the extent to which external economies are generated by the infant industry. The problem is that 'the concept of external economies is one of the most elusive in economic literature' (Scitovisky 1954: 143). This is one reason why in evaluations of infant-industry protection their existence is acknowledged but rarely given due weight. The importance of such externalities has been underlined and they are more widely prevalent in developing countries than is generally acknowledged (Stewart and Ghani, 1991). In the Brazilian case, such externalities did occur in the electronics industry, though it was fragmented. Particularly, considerable human capital has been formed and the Brazilian Banking sector distinguished itself by developing banking systems of international standard.

5.3.2.3 India

The Indian government has been influencing the computer hardware industry since the 1960s. Government policy initially protected the industry from foreign competition through high tariffs and quantitative controls on imports. Coupled with industrial licensing requirements, which severely regulated entry and exit of firms, such protection measures, no doubt, affected the speed and nature of technological progress in this industry. In 1971, domestic production of computers was entrusted to a sole producer- ECIL, a public enterprise. Similarly, by setting up Computer Maintenance Corporation (CMC) in 1976, the maintenance of estimated 400 computer installations was "indigenised" following IBM's exit from India. However, due to stringent policies governing foreign collaboration with domestic computer firms, Indian firms had little access to international technology.

Policy changes since the mid-1980s fostered domestic competition, opened avenues to -international and domestic technology sources, and encouraged the growth of efficient producers. On the whole, the growth performance of the entire hardware sector appears to be most impressive. The value of hardware production increased at an average annual rate of 19.8% between 1987 and 1991. Production of IT products - the largest segment of the hardware industry - increased from Rs. 20.7 billion in 1987 to Rs. 46.9 billion in 1991, reflecting an average annual rate of nearly 23%. The production of computers - the core of information technology - also registered an impressive rate of 22% per year during 1987-91. This includes micros, minis, super-minis, and mainframes to engineering workstations, peripherals and so on. Moreover, the pace of innovation in the computer industry has increased, and the technology gap with international producers of computers has narrowed (Rastogi, 1992).

Recognising that information technology (and electronics, in general) is a source of productivity improvement for the industrial and services sector, the government has singled out electronics for a series of policy reforms since 1985. This included gradual liberalisation of the restrictions on entry and exit. Flexibility to adjust both output mix and capacity in those sectors are still subject to licensing. The policy of reserving some products for small-scale-industry has been virtually eliminated. Access to imported goods assured through an open general license category. Since then, quantitative restrictions have been greatly reduced and import duty structure has been rationalised. More recently, since 1991, substantial reforms in trade and industrial policies have had significant impact on the orientation and competitiveness of the electronics sector. Many of these reforms have been particularly relevant to the software segment of this industry, which has been driven by a strong export orientation, while the electronics industry as a whole exported less than 6% of. Total production in 1991, the export of software is about 55Vo. A distinct change in the policy environment has also led to the recent interest of major IT multinationals to invest in India. Perhaps one of the most dramatic signals is the return of IBM for a joint venture with Tata Industries.

India's new policies for trade and industry make information and communication services a key need for both business and Government. IT applications are a source of major productivity gains and quality improvements throughout finance, manufacturing, infrastructure - as well as in agriculture, education, hearth, and public administration. Exports increasingly depend on timely market information, on computer-assisted product design, and on global electronic procurement and subcontracting. These practices are guiding foreign investment, technology transfer, and outsourcing. India is trying not to fall behind in adopting these business practices that have become essential to industrial competitiveness and economic modernisation.

Another limiting factor is the bureaucratic culture of the public sector. Indian public administration is notorious for unnecessary paperwork, excessively hierarchical management, inflexible personnel policies, and limited attention to service. In some agencies, resistance to the use of information systems is compounded by staff (particularly those in banks) that fears that computerisation would lead to massive layoffs. Changing this culture calls for selective and strategic applications of the IT and for complementary investments in change management. It also presents opportunities for redesigning work processes, reducing managerial layers, enhancing accountability and performance monitoring, and improving the quality of working life. We will expand this part later on when discussing the melting pot.

5.4 Institutional capability

5.4,1 Singapore

In the 1970s and the early 1980s, on-the-job training was the most common carrier path into the IT profession. Apart from the availability of computer science as an optional subject in the science curricula of the universities, there were no other formula training programs at the tertiary level. This situation prompted the CNC to focus on establishing new educational institutions specialising in the software aspects of IT. In specifying the requirements to be met by these new tertiary IT educational programs, the CNC emphasised two key themes. These were the adoption of business perspective in the planning and design of information systems and the inculcation of software engineering skills, based on state-of-the-art software technology, in order to deliver cost-effective and robust information systems (Hon, 1992).

New educational institutions specifically for IT were established, mostly in the early 1980s (ibid.). There is no doubt that these institutions are at the basis of the strong human capital formation that busted the confidence of Singapore to transform itself into an intelligent island. A Department of Information Systems and Computer Science (DISCS) in the National University of Singapore was established first. Students in this three-year program have to choose either the information stream or the computer science stream after the first year. This streaming of students according to business or technical inclination, has been effective in preparing graduates more thoroughly for their chosen career paths in the IT industry. The Institute of Systems Science (ISS) in the National University of Singapore was established to convert non-IT graduates to system analysts through an intensive nine-month postgraduate diploma Program. The institute was set up with the assistance of IBM Corporation. The Centre for computer studies (CCS) at Ngee Ann Polytechnic and Japanese-Singapore Institute of Software technology (JSIST) at the Singapore Polytechnic were set up with the help of ICL and the Japanese government respectively, to train diploma-level software technologists and programmers. They expand the poof of manpower available for IT jobs by drawing on students who would not be going to university.

Human capital alone cannot perform miracles of economic development. A host of institutions are required to support and sustain the efforts of it. When we specifically focus on IT, information and communications and R&D institutions become very relevant. Such a pivotal role in the microelectronics revolution in Singapore is being played by the Singapore Telecom. It is the sole provider of telecommunication services in Singapore. It has had the mandate to provide state-of-the-art telecommunication services at internationally competitive rates. Singapore direct dial and international leased circuit rates are among the lowest in the world. The range of services offered is also impressive. With push-button telephones in almost every home and office, and all telephone exchanges connected by optic fibre cables, Singapore Telecom is able to provide a comprehensive range of voice and data services. Its services include Integrated Services Digital Network (ISDN), the Televiews Videotext service, the DigiNet high-speed digital leased circuit service, Telebox electronic mailbox service and cellular telephone service. Through various submarine cable systems, radiating from Singapore, direct connections were made to the ASEAN countries, the Middle East, Eastern Europe, Australia, Hong Kong and Taiwan. To complement these links, the satellite communication infrastructure was expanded. Four INTELSAT antennae and two earth stations provide coverage of two-thirds of the world through the Pacific and Indian Ocean satellites.

Singapore's telecommunication infrastructure is among the most modern in the world. In 1989 World Competitiveness Report, Singapore's telecommunication infrastructure was rated 98.06 out of a maximum of 100 points, ahead of the runners-up, the united states and Canada. The pervasive and world-class telecommunication infrastructure available in Singapore has spurred a rapid growth in telecommunication traffic. In financial year 1988/89, the number of telephone lines increased by 6% to over 930,000, or about 35 telephone lines per 100 population, a very high ratio by international standard. The number of international direct dial (IDD) calls increased by 42% in the same period, to 45 million calls. At the rate of 17 IDD calls per person, this is one of the highest of the world. During the same period, the number of facsimile machines in use increased. 49% to over 14,000. There are now more than 205,000 pagers in use, one every 13 Singaporeans. New international services launched recently by Singapore Telecom included the international toll free service, the home country direct dial service, and the videoconference service (Hon, ibid.).

Although the telecommunications node for the Asia-Pacific area is clearly Japan, both Hong Kong and Singapore have been successful in attracting US and Western European TNCs' network hubs (Ken Ducatel and Ian Miles, 1992). Partly the success has been based upon low charge rates for international telecommunications traffic, at least in comparison to the Japanese KDD. For similar reasons, Britain is the hub for Western Europe, with most of the high-speed lines from the US terminating there. High-quality infrastructure and support are also important. Britain is in some cases the hub for Africa as Miami is used by many US TNCs operating in the Caribbean or Latin America. The poor linkage of US TNCs with Africa probably relates simply to the relative underdevelopment of infrastructure in African nations, with the exception of some North African and East African states.

Clearly, communications traffic within the Southeast Asian area is an important aspect of regional trade and development. With Singapore's lead in creating integrated electronic data interchange systems, and Hong Kong's attempt to create regional level satellite services, and the growth rates of traffic within each individual economy there are significant opportunities for economic development strategy wining the region as well as beyond the regional boundaries. This can be seen in the balance of Indonesia's international traffic between inter regional destinations and extra regional destination. If Australia is included within the region, over 50% of total international calls go to major Pacific Rim countries: Singapore (25%); Japan (10.7%o); Hong Kong (8.8%); Australia (6.9%). The United States, the only other major destination accounted for a significant, but relatively small I9.I%o (Datapro, 1991).

The latest technologies in telecommunications by itself do not make the economy more productive. It can do so only if there are conscious users capable to exploit the immense potential creatively. This is what Singapore tried to do and has already achieved a tremendous success. In December 1986 the NCB formed a project team to define the functional specifications of the TradeNet system, for Singapore is unique as a nation with an external trade volume of 3.5 times larger than its GDP. Together with the Singapore Trade Development Board, the Port of Singapore Authority and other government and private sector organisations, the team simplified trade documentation format and streamlined procedures for the declaration of imports and exports. It also specified the software requirements, carried out the system design, defined the EDI standards and selected the technical solution for the TradeNet system. Measures, which could improve the productivity of the trading sector, were, therefore, accorded high priority. TradeNet facilitates the electronic submission of trade documents by members of the trading community to the various government agencies and the transmission of responses from these agencies back to the sender. The government will also be able to interchange trade information and documents electronically to expedite the approval of imports or exports, port operations, cargo clearance and statistics compilation. TradeNet is the first electronic data interchange (EDII system in the world implemented on a national scale to link all parties involved in international trade (Hon, 1992).

In conjunction with the TradeNet conceptualisation and design studies, a parallel and supporting project, which involved detailed studies of four trade-related sectors – importers and exporters, freight forwarders, cargo agents and shipping agents - was carried out by NCB in conjunction with their hade associations. The objective of these studies was to produce the generic software specifications for the companies in those sectors to computerise their internal operations and integrate these with the TradeNet system eventually. A new government-owned company, Singapore Network Services Pte Ltd. (SNS) was formed in March 1988 to develop and operate TradeNet services. This company is jointly owned by the four government agencies, which are most involved in international trade matters. The TradeNet system runs on an IBM mainframe. TradeNet conforms to the EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport) international standard. To minimise development time, the company acquired and modified available EDI software for use in TradeNet. Several local software companies were commissioned to write software for companies to access TradeNet. These were developed in accordance with specifications laid down by Singapore Network Services. The system became operational in early 1989 (ibid.).

TradeNet simplifies the linkages and flow of information. Each TradeNet user needs to establish one link with the Trade net computer in order to communicate with all other users on the network. With TradeNet the preparation and submission of import and export declarations, and the cargo clearance process have been speeded up. Documents that used to take a day to process are now cleared in 13-30 minutes. Users are also freed from the restricted service hours for submission of declarations under the pre-TradeNet system. TradeNet has resulted in greater efficiency and competitiveness for the Singapore trading community. As of July 1990, 1,300 companies were linked to TradeNet andT1%o of trading transactions were being carried out on the network. By the end of 1991, it was expected that trade documentation in Singapore to be totally paperless (ibid.).

Singapore government has taken a proactive position in the development and diffusion of IT by creating and investing in a number of institutions in education, telecommunications, and the hardware and software IT industry in an integrated manner. This was possible, may be, because of the small size of the country but also the strong, authoritarian and entrepreneurial - government has played a significant part as well.

5.4.2 Brazil

The process of institutionalising information technology in Brazil can be linked to the establishment of the Special Secretariat for Informatics (SEI) in 1979. Soon was followed by the 'informatics law' in 1984, which reserved the production of a comprehensive set of IT goods and services for local capital. This policy succeeded in establishing a locally owned professional electronics industry and the potential of the Brazilian market for electronic products and services became visible. Self-reliance in information technology was a central component of the nationalism that cemented different alliances between various social groups and mobilised internal support for the policy.

The alliance that pushed-up of the IT policy in Brazil was made out of segments of the intelligentsia within and outside the state apparatus and some navy officers. Members of the intelligentsia within the state agencies, especially in the National Economic Development Bank (BNDE), the Studies and Projects Financing Agency (FINEP) and Co-ordinating Commission for Electronic Processing Activities (CAPRE), united with navy officers, concerned with national security, in common objective of local technological development, Backed by the Planning Minister, they provided the 'within the state' bunker of IT policy, a position they used to convince the relevant players inside the state apparatus of the strategic opportunity for establishing the policy.

Outside the state, members of the science and technology community organised in the Brazilian Society for the Progress of Science (SBPC) were the focal point at the beginning. Later, in the Brazilian Computing Society (SBE) and the Association of Data Processing professionals (APPD) constituted a relatively small but highly mobilised force that pressed the government for consistency in IT policy.

Brazil's government started to get involved in the development of telecommunications infrastructure for the country in 1962 with the approval of the Brazilian telecommunications code. That was the first time Brazil had a national policy for telecommunications. Until then, regulatory power was spread among local and state levels. As a result, Brazil had almost a thousand different telephone companies. Most of these were municipal, although some were private. In fact, it was the private Companhia Telephonica Brasileira who controlled most of Brazil’s two million lines. The presence of more than 900 different operators with incompatible systems was a big problem (Bibson, 1997). To solve this problem, The Brazilian Federal Government through the Ministry of Telecommunications created the holding company Telebras. It was meant to protect and develop the telecommunications industry. All competitive threats to Telebras were eliminated by a wholesale buyout of the 900+ small operators. At the end three independent operators remained. The first two were municipally owned: Ceterp in Ribeirao Preto (SP), and Sercontel in Londrina (PR). The last was privately owned held by CTBE, which operated in the heartland. All three were conveniently barred from operating in the long-distance market (ibid.). But even Telebras's expansion project had suffered from the economic crisis of the country and increasingly faced shortage of funds to keep up with the growing demand for telecommunications services. At present Brazil has 9.6 telephone per 100 people, which is very low compared to that of Southeast Asian countries. Hong Kong (54.7), Singapore (51.3), and Korea (43) have already caught up the advanced countries such as UK (52.8) or USA (64) (Word Bank, World Development Report, 1998199).

Public sector borrowing was not allowed to increase (owing to pressure from, among others, the IMF and the World Bank). The resulting cuts in government expenditure hit disproportionately the availability of long-term loans for investment in technological development of national firms. In Brazil the deficiencies of a long-term credit market and the almost complete lack of organised access to venture capital are seen as one of the main problems private firms have when they are faced with prospective investments in general and investments in technological development in particular (Erber, 1981). Thus the existing financial system has inhibited the development of technological capabilities in Brazil.

In the course of the 1980s, government expenditures for scientific and technological infrastructure diminished as a consequence of short-run stabilisation measures. The three main sources of funding public science and technology institutions (the National Fund for Science and Technology development of FINEP and the budgets for basic research of CNPq and CAPES) suffered sharp decrease. In 1985 they were allocated only 40 percent of the 1979 amount (Bielchowsky, 1985). The Brazilian situation was similar to that of Argentina, Mexico, Venezuela, Peru and Chile where stabilisation measures were introduced in the same period (Sagasti and Cook, 1987).

Economic policy in Brazil in the 1980s consisted of successive rounds of crisis management. The need to manage the external and internal debt and to control inflation dominated the government agenda. Pressing needs for short-term stabilisation crowded out work on long-term economic strategy. Concern with industrial strategy and technology policy existed, but there was not enough space to sustain such work. The IT policy was an exception, but the escape was only partial. Policy for this sub-sector suffered from not plugging into a supportive general industrial policy.

It seems that the early 1990s brought no relief. The instruments of market reserve were being dismantled and SEI, the institution that carried out the policy, has been demoted and marginalised and previous cadre of experts within government has been disbanded, and a process of unlearning was under way (Cassiolato, Hewitt, and Schmitz, 1992). Again, this has to be seen in the context of the severe economic crisis and the new government's desperate attempt to get this crisis under control. To be sure, there were forces in the government, which recognised that a new industrial strategy was part and parcel of overcoming the crisis and advocated a strategy to negotiate with national and foreign firms. In practice, however, such efforts were relegated to the margin, because the need to stabilise the economy took precedence.

The Brazilian case exposes clearly that fragmentation of institutions, supposed to work together towards the same goal of enabling the country to catch up in scientific and technological development for economic and social progress. Their inability to do what they were established to achieve was the main reason of their failure. This fragmentation occurred because of national IT policies and the macroeconomics polices were not in line. As a result of government failures in economic policy and provision of basic services, large sections of society were 'tired of the state'. In such an anti-government climate it was hard to sustain the case for strategic intervention in the electronics complex, even if the performance of government and industry in some sub-sectors has been relatively favourable. The recent financial crisis of Brazil shows that the country is still facing a big problem of different parts pulling in different directions, as is the case of some States not willing to co-operate with the Central Government in the payment of debts. The Real was devalued and another financial crisis is at hand. The vicious circle seems to be repeating itself.

5.4.3 India

In India, policies concerning the information technology industry have been shaped by her overall industrial and technology strategy, which emphasised the development of scientific, technological and industrial capabilities. This strategy had mixed results, with the costs of inefficiency and slow application and diffusion of information technology outweighing the benefits of technological deepening.

Based mostly on the work of Hanna (1994) we will give an overview of the institutions at work for the development and diffusion of IT in India.

There is no single apex institution or focal point for formulating national policies and strategies for the IT sector, not surprising given the size and complexity of India's economy and the recent emergence of this sector. But the Secretary of Department of Electronics (DOE), committed to defining the role of information technology in meeting national priorities, has indicated his strong interest in formulating a national IT plan - with World Bank assistance. The DOE has also created a national commission for the computer and software industries, with broad representation from public and private agencies.

India has made substantial investments in R&D for the hardware industry, and has developed impressive technological competencies in some areas such as advanced computing. Its Indian Institute of Science (IISC) has one of the most advanced artificial intelligence centres in developing countries. But it has few links or joint projects with local software companies. Most companies develop technologies internally, if at all. With few exceptions, software companies also have difficulty tracking trends and changes in software and hardware technologies developed abroad. Research institutions - typically more interested in technology development than technology capture or making existing technology work for India - are of little help.

A few but a growing number of Indian software firms possess some advanced technical capabilities that rival international competitors. But so far technology transfer from the large and dominant software houses to the small and medium software firms has been limited – due to the unwillingness of these large firms to subcontract to other software houses. The benefits of increased links between large and small software house could be substantial. Consider the adoption of Computer-Aided Software Engineering (CASE). A large Indian software company is marketing a CASE package in the United States. This package was developed locally. It allows for substantial increases in the productivity of software engineers. Yet, the adoption of CASE tools in India is meagre. Developments in CASE and its increased use by US software companies are likely to increase the productivity (and quality) gap between US and Indian software engineers, undermining India’s current comparative advantage in part of this market. May be the answer lies in its management thinking. The Indian firm is networked more with the US market than its home market because US markets are more lucrative than the Indian markets. But the failure of the Indian firm's managers is mainly the lack of understanding shown that the long term implication of their action is against their own growth where a weaker software industry will be a dragging force by making it less challenging and dynamic than it could be.

With the exception of the software services, state enterprises have dominated the strategic or high-tech areas of the electronics sector, while private consumer electronics firms remained domestically oriented. In terms of structure of the electronics sector, India has one of the highest ratios of production in the consumer electronics and the lowest in electronics data processing and in components among the newly industrialising economies. On the other hand, it has built a diversified sector and broad technological capabilities. However, the impressive technological achievements, particularly in the production of computers and telecommunication equipment, and in the development of an extensive science and technology infrastructure, did not lead to fully competitive production or to wide use of these capabilities by user industries and services.

Specialised marketing institutions and software publishers are missing from the Indian scene. Recent efforts to arrange delegations and seminars abroad and in India - by the DOE, the Electronics and Computer Software Export Promotion council, under the aegis of the Ministry of Commerce are evidence of it. Similarly, Indian financial institutions, lacking knowledge of the industry and its markets, have no reliable guidelines to give them assistance or confidence in evaluating software financing. Lending is based mainly on traditional manufacturing, where the means of production and outputs are tangible and the markets and technologies less volatile. It should be recognised that the Indian venture capital industry has started only recently, and has done well so far, and the long term prospects of the IT industry benefiting from such financial institutions are reasonably good. At present, however, India has few venture capital institutions, such as the Technology Development and Information Company of India (TDICD and Risk Capital and Technology Finance Corporation (RCTC). With few exceptions, venture capital financing has been inadequate, as measured by the share of funding used by Indian software firms. For example, in the USA, about 40 percent of venture capital has gone to the IT field, mainly software and related new services. In India, venture capital is estimated to have met only 1 percent of the capital requirements of the local software firms. Moreover, the availability of venture capital to software venture seems to be at an all time low in India in the last year or two. Hence, appropriate finance remains a critical and pressing issue at this stage of development for a dynamic and internationally competitive Indian software industry.

Two recent developments are also encouraging. One is the growing foreign investment in India's software industry. Many successful Indian companies have been financed to some degree by an injection of external capital. The second is the recent spurt of software companies going for public issues.

Telecommunication is a key part of the IT sector. It is driven by advances in software and microelectronics, and in turn, it enhances the benefits and helps diffuse information and information systems. India has extremely low availability of telecom services, less than what most competing countries have, 1.5 telephone lines per 100 inhabitant, compared with 7 for Thailand, 18.3 for Malaysia, and 18 for Pakistan (World Bank, World Development Report 1998/99).

The set-up for data communications in India is rudimentary. Among the large public networks are NICNET and INDONET. The National Informatics Centre (NIC) runs NICNET with its own nation-wide satellite-based network serving primarily government agencies in 450 cities. INDONET, run by CMC Limited, uses leased links from the Department of Telecommunications (DOT) and is operated mainly for computer time leasing. All in all there are eleven various network projects running, each with limited number of nodes, users, services and capabilities (Hanna, 1994).

The software industry association, NASSCOM, was established in 1988 as a source of technical information, as a conduit for energising the private IT industry, and as a mechanism for self-policing. But lately the government of India established seven Software Technology Parks (STPs) where 230 units have already been approved at Bangalore, Pune, Bhubaneshwar, Thiruvananthpuram, Hyderabad, NOIDA (near Delhi) and Gandhinagar. These STPs act as export-oriented resource centres for the member computer software exporting units, by offering general infrastructure facilities such as utility power, ready-to-use build-up space, centralised computing and high-speed data communication facilities (Correa, 1996). More need to be done to fully exploit the potential of IT industry and enhance the Indian competitiveness vis a vis that of NIEs of East Asia.

In general, the institutional framework is underdeveloped for dealing with systemic problems of computer and software requirements, planning, procurement, co-ordination among agencies, and IT diffusion. The IT associations are still in an early phase of development. It is rare for diverse industry and government groups to exchange ideas, define needs and requirements, and reach consensus on mutually beneficial goals and objectives in the IT field.

5.5 Human capital formation

To discuss the demand for II personnel, it helps to distinguish those who produce and deliver IT and those who use and apply IT. The literature on IT usually narrows the focus to three categories: IT specialists, Communication specialists, software and computer specialists. People, who have been trained in information science and technology, including such specialised users as librarians, fall into the first category. The Communication specialists include people trained in the technical and business aspects of the various forms of communications such as satellite, telecommunications, and broadcasting. The software and computer specialists are people trained in computer hardware manufacturing and maintenance or in computer software and maintenance. Here, we use these three categories of those involved in the production of IT and its use in all sectors of the economy.

Given the importance of a strong information infrastructure, governments can encourage IT use by investing in human resources and telecommunications networks. This should include broad-based investments such as support for general education and widespread provision of basic telephone service, both of which provide high economic and social returns in their own right. Development of a good information infrastructure, however, also requires investments in specialised human resources such electronics engineers, computer scientists, systems analysts and programmers, as well as specialised telecommunications services such as digital switching, high-speed data transmission and value-added networks. Such investments may be made in co-operation with the private sector, but experience shows that a government role is usually needed in building infrastructure, especially in developing and newly industrialising countries (Kraemer and Dedrick, 1994). The following section does focus on how the human capital development of scientists, engineers, and professionals in the IT area is being handled by the three countries: Singapore, Brazil, and India.

5.5.1 Singapore

Singapore has only its strategic location and its people as natural endowments on which to bet its future economic and social development. To exploit the location advantage of the island and make it the transit, service-hub, and trading centre of the region and the globe, Singapore had to heavily invest on human capital development. Singapore learns the latest in software engineering techniques from the global technology leaders. The professional IT manpower poof in Singapore has expanded from about 850 in 1980 to over 10,000 in 1990. The numbers of IT professionals produced annually by these programs is about 1,200. This will be increased to 1,600 by 1993, with the commencement of the new computer engineering course at the Nanyang Technological University and an increase in intake in the other programs. This means that Singapore will have produced at least 15,000 additional IT manpower from 1990 to year 2000. By then, every tertiary educational institution in Singapore will have a significant IT education capability. In addition there are a significant number of graduates trained in IT, returning from studies overseas (T.Mun Heng and L. Low, 1993). Even this does not seem to be enough because Singapore is looking the whole globe from where to get more scientists, engineers, and professionals, as we have already seen in the previous chapter.

Dovetailing into tertiary IT education programs is the availability of computer science as an elective subject in all junior colleges. Students, eager to begin a career in IT, can have an early taste of the subject as an academic pursuit. Each junior college is provided with a computer laboratory equipped with a local area network linking over 20 workstations. At present there are two universities, four polytechnics and eleven institutes of technical education. The government's target is to have 20% of every year cohort going to universities, half to polytechnics and the remainder receiving skills training in the institutes of technical education (Tang and Yeo, 1995).

It is possible to say that in Singapore an education revolution is taking place. Even kindergartens are using computers to teach small children, through music, sound, graphics and animation, certain skills in English, mathematics, and Mother Tongue (Wong, 1998). Computers are also used to improve the productivity of administrative work of schools, The Curriculum Development Institute of Singapore (CDIS) started, in early 1990s, the Learning and Writing with Computers Project, the Annual National Software Writing Competition for secondary schools, and development of a series of computer-based materials for the school

Mathematics curriculum (ibid.). The strategy is being shifted from computer literacy to computer as an information and educational tool at every level from kindergarten to the tertiary education. That means, learning will not be confined to only the class rooms because students will be involved in 'global learning' by using Internet from any place linked to the network system,

In 1996, a project called 'Student Teacher Workbench (STW)' (ibid.) was tested in six secondary schools, The project is, undertaken jointly by NCB and Ministry of Education with the participation from various computer manufacturers and software developers, looking for integrated computer-based learning, and management system which has two primary components: the teacher and the student. The system allows the teachers to teach, assess, monitor, and communicate with their students in a flexible way using different approaches to learning such as resource-based learning, exploratory learning, or co-operative learning rather than the traditional didactic method of teaching. At the same time, the students are able to learn materials customised to their abilities and needs, to learn at their own pace and be able to communicate directly with their friends, parents and teachers. Students are able to communicate with their counterparts in other regions, read the latest news, and get access to the local and worldwide multimedia materials to prepare assignments as well.

Singapore is doing all of these knowing that the future competitiveness of the country depends on highly trained manpower. This country has made a big leap forward in terms of IT skill development since the beginnings of the 1980s.

5.5.2 Brazil

In Brazil, implicit measures for IT training have been more significant than explicit ones. Implicit measures do not necessarily aim at human resources training as such. They consist of incentives (in particular trade, tax and monetary policy) which influence the production decisions of private firms. State investments in the education, training and research system are explicit measures. Brazil's own experience in the 1980s suggest that trade policy can be a very powerful instrument to bring about the training of human resources.

The human resources issue is particularly pertinent in the electronics industry. As O'Connor (1985) has argued, "The computer industry is essentially a knowledge-intensive industry wherein skilled, highly trained scientific, engineering and technical labour power is probably the single most important asset." Thus, the industry is characterised by an enormous demand for skilled labour. The shortage of supply of such labour has been well documented for the advanced industrial countries, particularly for software and hardware skills but also in areas of management (Ernst 1985; Soete 1985; Kaplinsky 1988). This was the case of Brazil. The IT market reserve policy has indirectly busted the in-house IT training in the country.

The 1980s decade there has been a substantial increase in the skill base of the electronics industry within the protected segments of computer production in Brazil (Hewitt, 1992). This increase is not only due to the expansion of the industry but also to the way that the industry has developed: generating in-house capabilities to both design and produce computers and peripherals for a range of market segments. While both the scarcity and the under-funding are real, it is not sufficiently recognised that a massive growth in human resources has taken place in spite of inadequate state provision. The bulk of the learning has not taken place in universities or technical colleges but in the computer firms themselves. But there are reservations when it comes to quality of training in such schools. For example of the 109 schools, public and private, in the state of 56o Paulo which offer courses for electronics technicians, only eleven were considered to be of adequate quality. Even though the number of trained electronics technicians far exceeds the number employed, 21,000 as against 3,200 in the period 1979183, there was still scarcity of technicians of adequate quality to match the needs of the electronic industry (ibid.).

If w look to the supply of engineers, the situation is even worse because the supply was by far short of the industry demand. Because of lack of technical and financial resources there was an enormous lack in the training and development of human resources for IT in the country (Ministry of Science and Technology, 1986 quoted in Hewitt, 1992). IT was in this situation where the public education and vocational training system cannot keep pace with the demand from and expanding industry, many firms have themselves taken on the task of training. In 1984, US$4.5 million was spent by the national computer and peripherals firms on the training of labour, with approximately 2 percent of total employment engaged in training activities (SEI, 1986 quoted in Hewitt, 1992).

It would be wrong to conclude that public educational provision does not matter if the private sector can make it. Educational institutions and private industry complement each other. In the East Asian NIEs, the State set favourable incentives for the private electronics sector and invested heavily in technical education. The latter is difficult in most LDCs because of the shortage of adequate financial resources (O'Connor 1985). But the Brazilian experience, an implicit human resources policy, is particularly interesting to developing countries where fund was always in short supply.

The essence of such an implicit policy is that the state structures earning opportunities in such a way those firms need to provide training in order to succeed. That structure was provided through the instruments of protection. This protection has not been without cost and some products have higher price than on the world market. To some extent this higher price can be seen as users paying for the training necessary for producers to be able to put these goods on the market. Given the difficulties of establishing an effective and equitable tax system in LDCs, this seems another way of recovering the cost of training.

The formation of human capital is more widely acknowledged to be source of technological externalities. In the Brazilian case such externalities were indeed generated by the protected electronic infants. If we compare the utilisation of labour in the national computer industry with that in other sub-sectors, which are not protected, it is possible to see that, proportionally, the national industry involved more human resources to local research and development. The benefits were only partially captured by the firms, which trained such technicians and engineers (Hewitt, 1992). Even though no systematic tracer study exists, there is known to be a significant movement of such labour to competing producers or – less often - to users. Sometimes they leave to set up their own firms. Indeed, most of the new firms, especially those producing specialised equipment and inputs were 'spin-offs' of the first generation of Brazilian IT firms (Schmitz and Hewitt, 1992; and Cassiolato, Flewitt and Schmitz, 1992).

As deregulation and open foreign competition becomes the norm in Brazil, then, firms will have to reduce their cost to meet competitors and as a result training budgets in the firms may become thinner and thinner. That is a call for the government to do more to keep up the competitiveness of Brazilian IT industry in the world market because it is related to higher skills and productivity of labour.

5.5.3 India

Software sector employment has expanded rapidly in many countries, including India, often during sluggish employment growth in the rest of the economy. Employment in the software industry increased faster in India than in most other similar countries. India has approximately 71,000 software and services professionals (Hanna, 1994: 48). The poof of scientists, engineers and related professionals in India is large, but only a relatively small number in that poof is trained for or employed in IT. Despite being small, the IT industry in India is diversified and complex, as in other countries, and it has many associated industries and services.

The core of IT labour force is its software personnel. In India the demand for trained software personnel far outstrips the supply, and the shortage is a major constraint to the industry's expansion. It places a heavy training burden on firms, results in high staff turnovers, and reduces the quality and competitiveness of the industry. Why the shortage? One reason is the substantial attrition of engineering school graduates, particularly from the IITs, and of experienced software professionals as a result of body shopping practices. Others include the scarcity of teachers and trainers, particularly in public education institutes, the irrelevance and poor quality of public and private (proprietary) training programs, and the high cost of in-house training (ibid.).

In the public sector, the quality and relevance of the training programs is very low. Only 275 industrial training institutes, polytechnics, colleges, and universities are qualified (and receive support) to conduct computer training - programs. But most of even this small number face shortages of qualified teachers, adequate equipment, and software and books - and they have weak links with industry and users (despite a 50 percent increase in the number of MCA graduates in 1991, only 5 percent were hired by software exporters). Because of the irrelevance of the training, employers prefer to recruit from only a few of these institutes, one large software house considers undergraduate and postgraduate students from only 30 universities (ibid. p.5l). In the private sector, an estimated 1,000 proprietary organisations produce about 80,000 trainees annually from courses ranging from two weeks to two years. Industry specialists estimate that 98 percent of the training organisations are below standard. Only about l0 to 14 percent of the larger organisations offer good quality programs. Between them they train roughly 40,000 trainees a year, with about 30,000 in basic two year programs to qualify for entry positions as programmers. The proprietary organisations also conduct executive training programs for computer and management personnel - mostly for large companies (ibid. p. 51).

The government of India should do more to ensure quality of training. The Indian case is paradoxical in the fact that few centres of excellence produce world class scientists and engineers and the vast majority of training and educational institutes produce mediocre quality.

5.6 The Melting Pot: IT management and economic development

5.6.1 Singapore

There are many key dimensions, which distinguish the knowledge economy from other phases of Singapore's development. One is having basic scientific knowledge and research as the economy's driving force, generating new technology, providing opportunities for innovation, creating new industries. Second, education increasingly plays a central role with the growth in knowledge services. Finally, new management approaches are developed and applied to organisations using computer technology and emphasising human resource management. In Singapore's experience, recruitment of foreign scientists and professionals is increasingly becoming important factor to enable the very ambitious vision of making the country competitive at the forefront of technology.

By economic criteria such as the conventional GNP per capita yardstick, Singapore seemed to have crossed the developed economy threshold by the early 1970s. But Singapore resisted the graduation into the developed country category on the argument that its economy is too dependent on foreign investment and is externally vulnerable. The World Bank World Development Report in 1990 classified Singapore, together with other Asian NIEs, as being among the industrial countries, as did the OECD. The OECD has also made calls to all four Asian NIEs to join OECD, though none has taken up the offer except Korea.

According to Hon (1992) by 1986, the NCB had made significant headway in achieving the objectives set at the beginning of the 1980s. The Civil Service Computerisation program (CSCP) was already having significant impact in almost every government department, with 23 computer installations, operating 50 mini and mainframe computers, and 370 information system professionals.

In the 1990 National R&D Survey, R&D expenditure stood at S$571.7 million or 0.9% of GDP. In terms of R&D manpower, 7094 persons were engaged either full-time or part-time, and of these 61% were research scientists and engineers (RSE). The expenditure per RSE in 1990 was S$132,000 compared to S$111,000 in 1987-88, reflecting the growing investment in R&D (Heng and Low, 1993.).

Singapore's successful growth and development has been attributed largely to public-sector led strategies, These strategies have maximised Singapore's historical comparative advantage of location, itself enhanced over time with infrastructure facilities, trained and disciplined manpower, and conducive business and investment environment fortified with attractive fiscal and other incentives (Heng and Low, 1993; Sisodia, 1992). The move to IT and advanced technologies, in general, by the Singapore's government was meant to avoid losing markets to cheap labour countries and exploit new opportunities. Changing comparative advantage indicated that greater gains were to be made from moving into high technology and high skilled activities. Another structural change is in terms of increasing 'servicization' of the economy into banking and finance, transport, communications and telecommunications, tourism and professional consulting services. In all these endeavours, efficient telecommunications, IT and related modern innovations clearly have important functions. In 1990, the service sector comprising commerce, transport and communications, financial and business services, and other services contributed 73.3Vo to total GDP and employed 6l.1% of the labour force (Heng and Low, ibid.).

During the period 1980-89, foreign companies comprising wholly foreign-owned and majority foreign-owned companies formed 21-23% of all companies registered in Singapore. They owned between 34 and 40% of total equity capital invested, defined as amount of paid-up capital and services of a company during the period. The balance of foreign and local ownership has not changed much but the magnitude of investment has increased more than three-fold. Throughout of the 1980s, the five top foreign investors were the US (share of 19.6% in 1980 and 19.5% in 1989), Japan (10.9% and 18.3% respectively), the UK 26.4% and 11.9%), Hong Kong (13.1% and 7.5%) and Malaysia (9.0% and 6.2%). However, their share of total foreign equity investment has fallen from 79.1% in 1980 to 63.4% in 1989, and only Japan's share has increased (ibid.).

From being a 'basket case' in 1965 when it left Malaysia, Singapore was transformed into a newly industrialising economy, one that, unlike South Korea and Taiwan, did not have large domestic bases. It adopted an outward strategy, which is highly dependent on foreign investment and MNCs. Although there are high costs of dependence and vulnerability in markets and technology to be balanced against the benefits of accelerated industrialisation, Singapore seems to have forged a successful partnership.

In short, when Singapore's labour surplus became labour deficit and the lower labour cost advantage disappeared, the logical step next was to upgrade labour skill and restructure the industry towards the high-tech. That is exactly what Singapore did. It immediately recognised that information technology as an infrastructure and as an industry was very strategic to the island's economy and determined to venture into it. Now, it has one of the world's busiest seaports in terms of registered freight tonnage and the world's leading container port all computerised. It has an extraordinarily efficient financial market in the Pacific Asia. Even after the recent financial crisis in Asia, Singapore is still continuing with its goal of becoming a top Asian financial centre by restructuring its banks and its financial system. It has opened its banking sector with new bank licences for foreign banks and scrapping limits on foreign ownership in local banks (Reuters, Monday May 17, 1999).

Singapore has been able to select IT as a pervasive technology and particularly suited to its economy, which is based on trade and services. In 1990, the *World Competitiveness Report* ranked it first in the world for the extent to which computer-based information technology is effectively used, and for the number of top managers understanding and using IT. Its IT policies and strategies were designed to serve the economy of the country. In this sense, we see a perfect match between S&T and economic policies.

5.6.2 Brazil

By the end of 1980s, Brazil had built up a significant platform in IT, particularly, in small computers, peripherals and various types of automation equipment for banks and industry due to the market reserve for national producers. Precisely because the policy was restrictive in the 1980s, the 1990s offer genuine policy choices about the degree of openness to imports and of collaboration with foreign firms (Schmitz and Hewitt, 1992; and Cassiolato, Hewitt and Schmitz, 1992). Relying on internally developed products was particularly efficient where strong user-producer relations were established as in banking automation (Cassiolato, 1992).

Many aspects of innovation occur through transactions between firms that are partially or wholly outside the market. The importance of such interactions on user-producer relationships in banking automation has been crucial in Brazil. Brazil's banking system is technologically very advanced. It has developed and adopted technological solutions suitable to local needs and conditions and some of the locally developed systems are internationally competitive in price and quality made possible by the protection of the local IT policy (Cassiolato, 1992). The importance of learning by interaction between producers and users cannot be not ignored (Carvalho, 1992). The externalities required to justify protection are not as is the case of digital control producers In Brazil. Demanding users are equally important. The fragility of users - in the case petrochemical firms - led to the underutilisation of the new technology. A comparative build-up was not achieved in software. This is mainly because it never received effective protection. Hence internal producer-user loops, essential for application software, rarely developed (Gaio, 1992).

The main defect of the Brazilian IT policy was that it did not feed into an overall industrial policy (Carvalho, 1992; Cassiolato, Hewitt and Schmitz, 1992). Brazil's experience shows that even within the electronics complex, there were different and conflicting regimes for telecommunications and consumer electronics, contributions also to the relative failure in semiconductors.

In spite of the enormous accumulation of know-how and skills, the achievements of 1980s remain fragile because of the country's economic crises. Studies of the differential impact which economic recession has for national and foreign firms' ability to produce computerised numerically controlled machine tools show that at the beginning of 1990s it is precisely the crisis which threatens to undermine the continued pursuit of long-run technological objectives (Porteous, 1992). Crisis management leaves little room for strategic industrial policy. The IT policy with all its limitations was an effective sub-sector strategy. It needed revising, but completely abandoning it may cause great damage to the whole process of technological learning.

Learning by interaction is seen as essential for attaining competitiveness. Such learning rarely develops if equipment is imported from far away. Case studies carried out in the context of the Nordic countries confirm this. For instance, Denmark's specialisation in dairy machinery, Sweden's in metalworking and wood cutting technology and Norway's in fishery technology cannot be credited merely to their factor-endowments. Closer interaction between producers and a competent and demanding user sector were essential in generating technological capabilities and in guaranteeing international competitiveness (Anderson et al. 1981). In other words, to place exclusive emphasis on either the production or use of new

Technologies are to lose out on the dynamics of interaction. Brazil's case confirms such Nordic countries' experience.

There is a strong case that country-specific user needs and a strong user-producer links shaped technological development in banking automation in Brazil. User designed their own automation systems and after failing to persuade MNC subsidiaries to produce machines that would fulfil their needs, they successfully developed and made systems in conjunction with domestic producers. Setting up user-producer links has never been an explicit policy target. However, in emphasising local production by national firms the policy permitted user-producer links to emerge. A more effective utilisation of the new technology requires that producer develop user-specific solutions. To do so, close interaction between users and suppliers of both hardware and software has proved to be essential (Cassiolato, 1992; Calvalho, 1992, Gaio, 1992).

The first period of IT sector development in Brazil shows a pattern of excessive vertical integration. Some authors suggest that such a trend is responsible for the inefficiency of the sector (Frischtak,1992). In fact, it was necessary to verticalise production in the early stages of the industry in Brazil owing to scale and tolerance requirements for inputs. In other words, firms which supplied mechanical parts, plastics and other inputs to other industrial sectors, such as the auto industry, were not interested in supplying to the infant IT sector or could not attain their more demanding specification level. As a result, at the beginning, IT firms had to produce even plastic boxes and most mechanical parts of their computers and peripherals. This has changed substantially by the end of the 1980s. A recent survey of suppliers to the IT sector shows a network of approximately 2,000 specialised firms supplying parts and components to the IT firms.

It should be pointed out that the foreign computer firms have contributed to the build-up of specialised suppliers. Not voluntarily, though, but because government policy forced them to buy locally. Thus the two bigger multinationals subsidiaries making mainframes in Brazil have around four hundred different internal suppliers of parts and components.

Apart from Brazil, the developing countries, which have followed the most restrictive policies toward foreign capital in electronics, are South Korea and India. In South Korea there has been a close collaboration between national political and industrial interests in electronics, which gave a strong basis for restriction of foreign capital, As a result the Koreans have been able to 'negotiate much superior technology transfer deals' (Mody, 1987). Similarly in the early days of the IT industry, foreign capital was uninterested in collaborating with Brazilian capital. By the end of the 1980s both foreign firms that already had production facilities in Brazil and those wishing to enter the markets were more amenable to negotiate with Brazilian firms and the government over collaboration. In the intervening years, there appears to have been some pay-off to the policy of exclusion. Brazilian firms have built up a considerable technological capability not only in manufacturing but also in R&D (Cassiolato 1992; Hewitt 1988). They have also increased their bargaining strength with foreign capital. In the first international bid for licensed technology for microcomputers, in 1977, no leading foreign firm was interested in supplying technology to Brazil (Erber

1990). In the second bid, for super-minicomputers in 1983, three large firms, DEC, Hewlett Packard and Data General, licensed technology to Brazilian firms. A recent survey of technological co-operation ventures between Brazilian IT firms and foreign suppliers listed 44 agreements involving 36 Brazilian and 34 foreign firms.

The Brazilian case does not fit in with stereotype views according to which locally produced hi-tech goods would not meet the technical standards of such firms. On the contrary the effective use of hi-tech is positively correlated with the establishment of local production and innovation capabilities. Furthermore, the behaviour of foreign firms both in producer and user sectors suggest that the key policy issue is not whether they should be permitted to play a role in industrial development. More important is the issue of how a developing country induces multinational firms and their subsidiaries to contribute to building up technologically dynamic industries. The IT policy in Brazil encountered increasing opposition in the course of the 1980s, from both outside and within the country. Indeed, internationally it has been one of the most heavily contested pieces of industrial policy. These pressures have contributed both to the relative success of this experience and to its limitations.

Since the mid-1960s till the late 1980s, Brazil has strongly followed an inward-looking economic structure based on the import-substitution strategy. The 'market reserve' for the IT industry is an extreme example of it. This policy had mixed results but it forced the country to learn and absorb the technology and helped in laying the foundation of indigenous IT. But it is hard to speak of well-organised and integrated S&T and economic policies. Even within the IT industry itself, there was clear fragmentation and lack of integration among the various sectors.

The Brazilian case shows that the absorption process of a new technology is a key determinant of the direction in which technologies evolve. In other words, the diffusion of technology and its development are simultaneously determined within any competitive market economy (Metcalfe, 1986). The environment shapes the pattern of technical evolution, which in turn redefines the environment. Different diffusion environments generate different patterns of technical advance (Georghiou et al., 1986). This means that there is country/region specificity in technological design. This is why the early stages of the development of a technology are so important for Third World economies according to neo-Schumpeterians (Freeman 1982). The proximity of the users to the suppliers of an innovation plays an important role in the design and de-bugging of new products, especially hi-tech products. For this process to be successful, or even possible, the supplier needs ready access to a reasonably large constituency of potential users with the complete range of skills necessary to apply the innovation successfully or the expertise necessary to formulate problems for the innovator to solve (Walsh, 1988). As Katz (1987) pointed out, the empirical evidence shows that manufacturing firms in least developed countries make much less use of subcontracting than their counterparts in advanced countries.

5.6.3 India

The Indian experience is mixed. A study, which examines the Indian computer industry up to the late 1970s, concluded that the policy of exclusion of foreign firms had opened up opportunities for local development of industry (Grieco, 1985). Similarly, Heeks (1991, 1998) argues that the restrictions on foreign capital in the 1970s helped to establish a local hardware industry with some internal capacity but he concedes also that many see the 1970s as something of a 'lost decade' for India in computing terms, In 1984 the policy regime was liberalised in a number of ways including some removal of import restrictions and duties and opening up to foreign capital and India's image and activity as a global software player began to take off. This liberalisation seems to have had a two-fold effect. New firms established since then have relied mainly on screwdriver technology that is the assembly of copied products, often licensed from foreign firms. In contrast, those national firms established in the 1970s appear to have negotiated agreements with foreign firms, which further their internal technological capabilities.

National spending on computer hardware and software in India was about 0.4 percent of GDP (1990), which was lower compared with software competitors - 0.6 for Mexico, 0.8 for Korea, 1.1 for h-eland, 1.3 for Singapore, and 1.4 for Israel. Most OECD countries spend between 3 and 5 percent of their GNP on hardware and software. India's information sector is also smaller than other Asian countries. Total value of output of information goods and services in India is estimated at 11% of GDP, compared to 26% for Singapore, 15% for S. Korea, and 14% for Malaysia (Kelkar, 1991). In terms of IT penetration into various sectors of the economy, such as manufacturing, transport, and finance, IT remains relatively marginal to corporate strategy and operations. Few small and medium-size enterprises use IT.

As far as computer hardware is concerned, India has some way to go in order to become internationally competitive. The entire hardware industry for instance, including consumer electronics and electronics components, is predominantly domestic market-oriented. According to Hanna (1994) less than 6% of hardware production was exported in 1991. As with production, the exports of hardware witnessed a significant drop in 1991, largely due to reduced exports of IT products, which accounted for over 75% of total hardware exports in 1990. Similarly, computer exports dropped from a peak of Rs. 2.9 billion in 1990 to Rs. 1.8 billion in 1991. The share of hardware revenue in total IT production has dropped from 44% in 1990 to 37% in 1992, and profitability is under increasing pressure with the gradual liberalisation of IT imports. But the total domestic hardware market has increased dramatically in the last years.

One of the main reasons for poor growth performance of domestically manufactured computer hardware and peripherals appears to be their excessively high prices, which have restrained effective demand for their use (e.g. microcomputer prices were twice higher than international prices). These high prices are, in turn, to a large extent, the results of high tariffs and other restrictions on both imported inputs as well as imported computers, indicating that policy changes have not gone far enough in enhancing competitiveness in this industry.

The Indian software industry, although small by industrialised countries standards, has been growing at an exceptional compound annual rate of 21 percent between 1987 and 1991 in total, and 35 percent for exports. This growth is considerably faster than the 15 percent rate in the United States during the 1984-87 boom period. However, when compared to the total industry performance of other competitor countries, India appears to be behind all of these countries except Israel (ibid. p.28). Indian software is in many respects still an "infant". Except for a few large firms that have become established as industry leaders, it consists of mostly small firms at a relatively early stage of professional organisation. The business know-how and computer expertise of the Tata Group- Tata Consultancy Services and Tata Unisys Ltd. - and CMC, a public enterprise, have greatly contributed to early efforts to build the software industry. Over three-fourths of the companies have fewer than 25 professionals. The structure of the sector is highly concentrated with the top three vendors each selling more than US$10 million in software services and products. Approximately 95 percent of firms had software revenues of under US$100,000 per firm. A growing number of companies have exceeded $1 million in sales: from 15 companies in 1990 to 44 in 1992; and 27 of them have exported over $l million each in 1992 (ibid. p.31).

The export growth has come mainly from the provision of contract programmers to carry out low-level work ("body-shopping" or "manpower contracts" in which the overseas buyer typically buys "hours" and not a total project or product with the associated management and high value-added technical services). Indian firms undertake mostly the routine tasks of coding and debugging - rather than higher skill tasks of design, analysis, and project management. These contracts are generally short in term, low in risk, low in value added, and low in investment, but they represent 70-80 percent of the country's export revenues. Typically, programmers are contracted out to work for a client at an agreed hourly or monthly rate for six to eighteen months. They perform data conversion or coding jobs, such as conversion from batch processing to on-line systems or conversion from source code to UND(-based systems. This has several undesirable aspects (ibid. p 32-33).

Indian software services enjoy the lowest labour cost after China. It has one of the largest pools of labour supply, and has the advantage of Engli.sh speaking. But, compared with competitors, India has the disadvantage of poor telecommunications infrastructure, and is not above parity regarding the availability of specialised education and training and several other criteria. Moreover, it has yet to exploit the 'potential' competitive advantage of a large domestic market. This could help in acquiring experience in higher value-added segments of software services and in tapping foreign expertise through joint ventures and direct foreign investment (InfoTech, 1 992).

The software industry has been constrained by a number of factors such as underdeveloped domestic market, weak marketing, the inadequacy of finance mechanisms, the inadequacy of data communication infrastructure, the shortage of high quality software engineering education and training. Add to these the lack of policies concerning public procurement of software and software services, import restrictions on hardware and software, and lack of legal protection for software. Any strategy that wants to accelerate India's IT sectors and optimise the sector's performance will have to address these issues.

India, as a big country, could use IT as an infrastructure to improve the productivity of other sectors. In fact, there are several large on-line transaction systems, including the railway's passenger ticket booking system and the Indian Airlines passenger reservations and departure control system. The railway's application, carried out by a local software company (CMC), provided a demonstrated effect of IT contributions to improved services for more than 11 million passengers a day, more than the total population of Belgium. It has reduced waiting time in the reservation queue from 80 minutes to five, and is reducing corruption as well. The Railways recently has proposed computerising freight and equipment trucking. But substantial improvements remain to be realised in the management of railways.

India has been very slow in exploiting the full potential of IT to improve the government civil services, transport and communications, tourism, the financial sector, and trade in general. For example, computerisation of the Bombay Port and other major ports and customs is an imperative for expanding exports and attracting foreign investment. Moreover, national distribution systems for such basic inputs such as fertilisers and for basic foodstuffs could benefit substantially from improved databases and from computerised decision support and monitoring systems. The same could be done in the banking sector. The financial sector is one of the largest markets and earliest adopters of information technology, and in many countries financial applications have been a driving force for the development of a large local market for IT. In India, however, numerous constraints have retarded the adoption and productive use, among which is fear of labour redundancy, of modern information and communication systems by financial institutions and insurance companies.

The government of India has always been criticised for red tape and inefficient bureaucracies. Politicians are increasingly looking to IT as a means to reform the public sector. The major aims are to increase efficiency, decentralisation of decision making, increase accountability, improve resource management, and marketisation (increase the use of market forces to cover the public sector where citizens and government are taken as customer-supplier). But India will take time to reform the public sector in a way that makes a difference for at present politicians either are ignoring it totally or idolising it as if the technology itself does the expected change. (Heeks, 1998).

The general conclusion we make of India in terms of IT and economic policy integration is poor. The change in the IT industry is not well integrated. The few pockets of excellence are isolated ones. India needs to do more to really be a real international competitor.

6

6. Conclusions on NIEs

Each of the NIEs represents different types of industrial development. Each country has a particular choice among strategic variables: the promotion of selected industries or of selected enterprises, fostering of particular types of industrial structure, reliance on domestic as opposed to foreign ownership of industry, and development of an indigenous base of technology and skills. Every choice requires different degrees and combinations of selective and functional interventions. It is not possible to talk in terms of one best long-term development strategy. The experience of the successful developing countries shows that different combination of incentives, capabilities and institutions, can lead to technological mastery.

We need to recognise the limits and strengths of markets, as well as the strengths, and limits of government interventions aimed at correcting market failures (Stiglitz, 1989). Empirical studies have shown now and again that in developing countries markets do not function properly, hence, the need for government intervention. But at the same time the experience of developing countries is replete with instances of misguided intervention. Many of these failed interventions were neither economic nor truly selective. The relatively few cases of successful selective interventions that exist suggest that interventions are necessary in the widespread market failures. Consequently, improved methods of intervening are worth striving [or. Much depends on the competence, honesty and political strength of the policy makers: where governments are so weak or corrupt that selective interventions inevitably lead to the "hijacking" of policy by entrenched interests. Only then it is possible to say better to suffer market failure than pervasive "government failure" (Biggs and Levy, 1990).

In this concluding chapter, we are going to evaluate and summarise all the experience of our sample NIEs based on the criteria developed in chapter 3 section 3.3.5. We have grouped them under S&T and economic policy integration, priority on IT as a pervasive technology, institutional capability, human capital formation, and technology and economic development. Besides, the lessons learned in terms of sustainability, flexibility and transferability, quality, priority and result have been given. We have kept the major lessons on IT separately at the end of the chapter.

6.1 S&T and economic policies integration

The experience of Brazil shows us that the neglect of essential relationships between technology policy and general macroeconomic environment could be very costly. In fact, in Brazil the scientific capability created did not contribute much to the building up of innovative capabilities. Thus, the economy did not benefit much in improving its international competitiveness. At least it remained behind that of the Southeast Asian countries. This is true with the exception of certain areas like the aircraft manufacturing, minicomputers, special steel, and armaments.

Brazilian strategy, despite its heavy investments and major successes in some specifically targeted areas was to a large extent ineffective in achieving competitiveness for large parts of industry. It has set up large public enterprises and restricted foreign entry in certain sectors in an import-substitution framework. It did not effectively use the big government purchasing power to push technological development. It lacked a comprehensive scheme to promote the diffusion of technologies, particularly in the case of pervasive technologies like IT. On the .supply side, it did not sustain R&D activities by providing the necessary funding and establishing an effective system of co-ordination and planning. Its scientific institutions were more biased towards the natural sciences.

India, on the other hand, from the outset followed the centrally planned and managed economic system, ala Soviet style in otherwise politically democratic society. It gave priority to the development of the heavy industry to be led by the public enterprises. Indian government was suspicious of private enterprise in general and large private firms and foreign investors in particular. Thus, barriers to entry, exit, growth and diversification were the pillars of the Indian strategy. Centrally planned prices and physical targets were the tools in the hand of government bureaucrats, which increased tremendously their power and led to corruption and inefficient administrative system. In all this process, India set up large network of S&T institutions, but these were divorced from manufacturing enterprises and were excessively bureaucratic organisations.

Unlike that of Brazil and India, the other four Tigers did much well. They all invested heavily in technology innovation that was primarily oriented to commercial needs of productive enterprises and have in the process produced a large poof of scientists and engineers of high quality. Their policies were centred on the goal of creating internationally competitive industries.

Hong Kong stuck to its light industry without pushing in the technological upgrading of its manufacturing industry and has built its economy on light industries based on simple technologies, lately increasingly investing in mainland China to exploit the available cheap labour'. Of course, is has continued to build world class financial institutions and as a trade centre.

Korea went the indigenous technology development and its policies consistently followed the path of technological independence. Korea protected and promoted strategic industries, set up public enterprises, directed investment at the sector and often the firm level, and promoted exports by several direct measures. It did intervene in technology transfer agreements and technology development, restructured industries and enforced labour training. Even today a strong element of guidance remains in place. Particularly, it encouraged and facilitated the building of an industry capable of achieving economic of scale to improve international competitiveness through the Chaebols. Heavy investment in S&T research through the various private and public institutions were designed to enter the high-tech industry like the semiconductor, auto industry, and electronics industry in general.

Taiwan also protected emerging industries, guided expansion along peculiar lines and had a very active technology development policy. It mainly differs from that of Korea in not going for big firms (Chaebols in Korea), but rather concentrated in providing support to small and medium-sized firms. This strategy proved to be more flexible and less risky than that of Korea. Of course, the more risky South Korean strategy permitted larger leaps into high technology activities.

Taiwan and Singapore followed the path of partnership with TNCs to learn and master the foreign technologies and clearly pushing for high-tech industries. Singapore in contrast to South Korea and Taiwan relied entirely in technology generated elsewhere but intervened selectively to induce investors to move up the technological scale and provide a well-trained workforce. This might give a false impression that Singapore was less interventionist than the other two, not at all. In fact, Singapore has earned the name of 'technopreneurial nation' to mean that the country is managed by an elite group, like you manage an enterprise.

Generally speaking, Brazil and India are more advanced in science than the Tigers while these are more advanced in industrial technology (Reddy and Sigurdson, 1997). This is to mean that Brazil and India have advanced science base, which is working on conventional technology, while the tigers have low science base but working on advanced technology. The strategy followed by the tigers is more sustainable in that their industrial revenue is allowing them to invest more to advance their science base, what they are doing aggressively. The strategies of Brazil and India have shown difficulties in terms of sustainability because of their recurrent economic difficulties and they need to do more to keep the balance.

6.2 Priority given to IT

Singapore, like South Korea and Taiwan, has given priority to the IT industry and this has grown tremendously and its export value, in some cases, has even surpassed that of textiles. To a lesser degree this is true also of Hong Kong. But Singapore seems to emerge high above all the others in the IT infrastructure development.

Singapore's vision and IT policies, all point into the direction that IT is a priority. While that of Brazil and India, IT policies are mainly the result of import-substitution strategies or as part of the broad S&T policies. Singapore is building its economy around IT. It all started in early 1980s with civil service computerisation and IT skill development to support the expansion of the indigenous computer software and service industry in general. A decade later', it jumped to a more ambitious plan, the IT 2000 master plan, to change the island into an intelligent global city.

Singapore chose IT as a priority technology because of its pervasive nature and jumped into it to exploit the new opportunities of the first comer and retain its position as a trading and service-hub in the region. It was meant to improve the productivity and competitiveness in every sector of the country's economy and to continue to develop a strong export-oriented IT industry. This was to be achieved, as the usual trick of Singapore, by attracting and motivating the TNCs. Now IT infrastructure of Singapore is becoming the envy of many countries. Singapore is the first country in the world with an advanced nation-wide information infrastructure, which allows computers in any part of the country to be interconnected both to one another and to other computers located anywhere else in the wor1d.

We don't find a vision driven IT development in Brazil. The 'microelectronics market reserve’ concept launched in the mid-1970s was based on the classical import-substitution model. It was meant to create national capability in IT and reduce technological dependence as well as using IT as an infrastructure to strengthen the economy and its defence force. The idea of international competitiveness in IT manufacturing industry was remote. It did succeed partially because the whole IT policy was not well integrated and the economic crisis of the country made it difficult to sustain more investment in IT.

India's strategy for electronics, in 1970s, was to achieve an import-substituting, self-reliant, public sector led growth with very little role of monopoly houses and foreign companies. While its software industry emerged in 1980s, more to globalisation trends rather than a conscious policy-led results, and Indian politicians were quick to link it to Indian public administration reform (increased efficiency, decentralisation, increased accountability, improved resource management and marketisation). This enabled it to get some attention from the politicians and more policies to help the diffusion of IT are likely to come. The slow liberalisation process started in the 1980s is going to help increase the international competitiveness of Indian IT industry as a whole, particularly that of IT manufacturing.

6.3 Institutional capability

Braz.il did invest considerable money for institutional development such as R&D institutions, higher education institutions, defence research and heavy industry. But it is hardly possible to say that Brazil has an integrated 'national innovation system'. Its S&T institutions in general in the past were fragmented and could not effectively solve problems beyond their individual capabilities and their conflict of interest could not bring them together. Besides, its institutions were frustrated by lack of adequate funds to sustain their growth. A bias towards the basic sciences as opposed to applied technologies was clear weakness that made sustainability difficult. Nonetheless, Brazil has been able to establish institutions to support local innovations such as providing quality control systems, help adaptations and acquisitions of foreign technologies, providing national consulting services and scientific and technological information centres. Since institutional maturity can only be measured by the result achieved in the international arena rather than by the number of institutions established, Brazilian institutions as a whole did not perform particularly well compared to the Southeast Asian countries as measured by international competitiveness.

India on other hand has some traits similar to that of Brazil, but always in its own unique way. Both countries are similar in not been able to create S&T institutions well integrated into their economic systems. India is well known for its world class institutes of technologies and R&D institutes, but failed to tap all the scientific and technological outputs for commercial development and improve its international competitiveness. S&T institutions were build on the premise of the 'free play of intellect', which is at the root of divergence of interest between industry and the scientific institutions. These two sides could have been integrated by a well-thought macroeconomic policy that includes and defines the contribution of S&T institutions to the development of industry and society in general. This was absent in India. It was also true of Brazil to some extent. For example, the typical paradox of India can be shown in its excellent R&D institutions in IT hardware industry where some impressive technological competencies in advanced computing such as artificial intelligence have been achieved. But it did not properly create links or joint projects with local software companies to commercially exploit it. The institutional break between the S&T institutions and industry is made clear again, which retards the achievement of international competitiveness. Of course, India's case was more complicated by the huge number of administrative institutions because of the path of planned economic development. These multiple controls of its macroeconomic policies resulted in large price distortions and led to inefficient use of resources and the consequent lag in international competitiveness.

The Southeast Asian countries are a different class from the above two, Brazil and India. They were particularly good at recognising early enough the importance of international competitiveness as the long-term test for sustainable economic development. All their S&T effort was directed by this very idea. That is why Korea and Taiwan, like Japan did it before, were very keen in identifying key industries to nurture and lead to maturity with all the means available to their governments. Korean institutions were very busy creating and supporting big private conglomerates, the Chaebols. Korea has succeeded to enter into the international market in high-tech industry in big leaps. The price paid is a less flexible oligopolistic economic structure that emerged. Its particular weakness has been particularly evident in the recent financial crisis of East Asian countries.

The intervention of the Taiwanese government, on the other hand, has succeeded following different path to that of Korea. Taiwanese government institutions, the myriad of small and medium-sized enterprises (SMEs), and the TNCs and foreign buyers have been able to forge an integrated institutional framework beneficial to all parties. Globalisation trends and outsourcing in manufacturing opened an opportunity for the Taiwanese SMEs to specialise at the foot of TNCs in specific niche markets. But slowly and surely some Taiwanese firms are emerging to compete in the international arena on their own with their own brand names (example ACER). The government selectively intervenes, usually through joint ventures; in the development of strategic technologies that could enable Taiwanese companies remain competitive in the international markets (example IC industry). The typical Taiwanese economic structure dominated by the SMEs makes it more flexible and less risky to manage and adapt to changing global trends.

Singapore's institutional capability is made evident by the world class infrastructure and institutional support to economic and social development of the country. The government, as an institution, is strong and efficient. Singapore politically has no diversity and is dominated by a single party where divergent political views are not encouraged. On the economic side, it is wide open and TNCs consider it the second home. Its education and training institutions are of very high standard.

Educational and training institutions in Singapore are among the best in the world. The telecommunications infrastructure is among the most advanced in the world. The Port of Singapore is one of the best in the world. TradeNet of Singapore is the first electronic data interchange system in the world implemented on a national scale to link all parties involved in international trade. Its financial institutions are of international standard in direct competition to that of Hong Kong. It has class transport and communications and catering services. Most of all, these different institutions work together in perfect harmony in the knowledge that they are interdependent.

Hong Kong is the least interventionist country from among the NIEs we are discussing. It has been able to create a lean and efficient administration, sound and transparent legal system, and free information flow. IT has been able to create a financial institutional capability of world class, fifth largest banking centre in the world. Its financial sector is considered very good with suitable institutional and regulatory framework left to the market. After 1997, Hong Kong is back under Chinese control. New institutions are created to make possible the 'one country and two systems' work in harmony. But its institutional capability to upgrade its manufacturing technology is lagging behind the other tigers.

6.4 Human capital formation

The East Asian NIEs have the largest stock of human capital relative to their size, in a broad sense, while Brazil comes next to them and India is at the bottom of all. India has the largest absolute supply, although of highly variable quality, and graduate unemployment and brain drain are real problems. The same pattern is again found with regard to training and engineering education and quality of education with the East Asian countries leading and Brazil and India following.

South Korea and Taiwan are in a different class from Singapore and Hong Kong. They have larger relative technical skill endowment and they are capable to tackle more complex and demanding industrial technologies. Hong Kong is behind even Singapore. Reverse brain drain has been observed in Korea and Taiwan, while Singapore is aggressively recruiting from the international poof of skilled manpower, particularly scientists and highly skilled professionals.

Coming to IT skills and comparing Singapore, Brazil and India, we find that Singapore has made a tremendous progress while Brazil and India did less. Singapore starting from a pool of only 850 IT professionals in 1980 has increased the poof to about 25,000 in 1999. On the other hand Brazil and India have not been able to keep up to the demand in IT skills, particularly quality wise. The growth of IT skills in Brazil was particularly attributed to the side effect of the 'market reserve'. Computer firms themselves were producing IT skills to meet their needs through the in-house training. In India the demand for trained software personnel is greater than supply, and the shortage is considered a major constraint to the expansion of the industry, given also to the acute problem of brain drain of the top skilled group. This is because the quality and relevance of training in the public sector is very low. Very few, between l0 to l4 per cent of the larger organisations offer good quality programs.

6.5 The melting pot: technology management and economic development

Policies, institutions and skills are always found together and they are inseparable. Policies and strategies show the path to the achievement of the national economic development goals. Institutions become the instruments to blend vision and objectives of the country to that of the firms and individuals to make sure that everybody is pulling in the same direction. S&T policies can be best tested on the ground if they are able to bring about the economic and social benefits to all the involved parties. Institutional capability matures when the individuals, with their talents and skills, feel fulfilled in the role given to them to play by the organisation in which they work. And the organisations, in turn, feel the same .in relation to the industry and the country in which they operate. When all these organisations work complementing one another and work in harmony in an atmosphere of continuous learning and improvement, then, one can hope the country is in the right track to develop the full potential of its institutions. But the final test remains the competition in international arena. When these institutions are capable to work better in some services or products relative to other competing institutions from other parts of the world, then, the wining relationship has been found and that leads to greater international competitiveness.

Now and again it has been proved that in advanced technology, government intervention can work wonders if properly timed and managed. A classical case, of timely and selective intervention, is the Silicon Valley in Santa Clara county, California, where the semiconductor industry is based, was a ‘peaceful agricultural valley' in the 1940s (Saxenian, 1985). In the 1950s, a few firms moved to the county to take advantage of the science-park set up by Stanford University. By 1970 the region has gained international fame with highest concentration of high technology enterprises. The history of Silicon Valley presents an example of how an industry dependent on the science-park in turn generated substantial and significant externalities both within the industry and with rest of the economy. Government support was vital in nurturing the nascent silicon industry in the early 1960s. Prior to WW II, the US electronics industry was less developed than the British or the German. But Europe lags behind the United States in this industry now. This development has been attributed to the catalytic role of the government in the United States (Malerba, 1985; Saxenian, 1985). US defence and space programs provided the market and the funds for the industry.

This is not confined only to microelectronics technologies. In the 1950s, growth in agricultural production and productivity in Punjab was relatively low, but since the 1960s it has consistently exceeded the national average. From 1965-66 to 1978-19, cereal production in the Punjab grew by 1Q.7Vo per year compared with 5Vo for the whole of India. The adoption of new technology, for wheat in mid 1960s and rice in the early 1970s, was the main lesson for this change in performance. Markets were undeveloped and the government had to do something about it. Five areas were identified to generate substantial externalities in agriculture in Punjab: technology development, irrigation, credit, informational markets, and human capital. In each case, government policies acted to offset market weaknesses (Stewart and Ghani, 1991).

A clear area where the government needs to intervene is in the development of skills. As development proceeds, more difficult technologies are used and the need for more sophisticated and specialised education/training grows. To the extent that the education "market" lacks information on these specialised needs, or under invests in providing facilities of the right kind and quality, there arises the need for selective intervention. Moreover, since there is a serious risk of private under-investment in training at the firm level when labour is mobile, human capital development requires measures to induce more investment to support employee training, by firms individually or co-operatively, or by governments where private agents consistently under invest. These measures may be functional, applied to all activities, or they may be selective, targeting emerging sectors.

The policies must also cover the development of institutions external to firms, to provide information, standards, basic research and other similar "public goods" relevant to capability development (Grossman, 1990). As development proceeds, moreover, institutional interventions may grow more selective as the initial basic needs are met and markets function more efficiently.

Therefore, the development of capabilities is the outcome of a complex interaction of incentive structures through government interventions to overcome market failures to form the necessary human capital, to increase the technological effort of the country and develop the necessary institutional capability to support the economy achieve international competitiveness. It is the interplay of all these factors; in a given country settings that determine how well individual producers learn the skills and master the information needed Chapter 6 Conclusion: Newly Industrialized Economies to cope with industrial technologies. The same can be said at the national level, how well countries employ their factor endowments, raise those endowments over time, and grow dynamically in the context of rapidly changing technologies is very crucial to increase their international competitiveness. Thus, S&T policy and management is a very complex issue. To look for one single best approach is not wise. Determination, persistence and long-term view of capable governments are very crucial. Clear policies, well-trained and skilled manpower, strong institutions and their co-operation and networks are always at the basis of successful development. Obviously all of these require huge investments and long-term commitment anything less cannot produce results. Since the developing countries are disadvantaged from this point of view, they need a great deal of international assistance, particularly the least developed among them, to help them help themselves.

The information technology sector may be viewed as a source of productivity growth in all economic sectors - that is, as an important infrastructure - and as an industry in its own right. This study supports both views but emphasises the first, since this is where most of the benefits are likely to come from for late comer industrialising countries. Governments can play a catalytic role in developing this infrastructure and in piloting and demonstrating various services to utilise the new infrastructure and stimulate the effective use of these services in support of economy-wide competitiveness.

Governments are influencing the overall development of the IT industry in both the advance and developing countries. They have also invested heavily in the computerisation of key public and social services, tax and customs administration, public financial management, public infrastructures, and public information services. More recently, public sector agencies are learning to use information technology to promote decentralisation, co-ordination and accountability. During this process, many mistakes were made and lessons learned.

6.6 Lessons Learned from NIEs

General lessons

There are important general lessons learned from the experience of the NIEs. The most important are classified into issues of sustainability, flexibility and transferability, quality, priority and result.

1. Sustainability

To use S&T as a base for economic and social development successfully, one needs to build it gradually in a sustainable manner.

- Investment made today in S&T should be sustainable also tomorrow. A classical example, we have it in the Soviet science and technology system. It was serving mainly the Soviet military power and was not linked to economy of the country and proved to be unsustainable. Soviet Union collapsed and its scientific institutions as well. Entire science cities have been abandoned and become ghost cities unable to sustain their continuity. India particularly seems to have, to some degree, followed a similar pattern but long-term sustainability will become difficult if it is not linked soon enough to the economy. Brazil's S&T movement was linked to the military government at the beginning emphasising nuclear research. Its bias towards the basic sciences may be traced to it. While the East Asian countries emphasised the light industries before going to the more demanding heavy industries and high-tech industries for the same reason of sustainability and have succeeded. They have outperformed, in economic terms, both Brazil and India.
- Skill generation and retention should be sustainable and should grow with demand. The other advantage of starting from the light industry is that they are less skill intensive. At that stage brain drain can be less problematic. As you climb the ladder of higher technologies you need higher skills and brain drain problem becomes serious. Retention of skilled workforce should be given importance. If the economy is growing, as it did in the East Asian countries, then reverse brain drain will also possible. But as the case of India proves it, developing huge number of skilled manpower without in parallel developing the industry to absorb them for long time does lead to heavy brain drain problems.
- Proliferation of institutions in not sustainable. This can happen when the activities of various ministries are not co-ordinated and they have a free hand. They can make more damage than they can help because duplication is inevitable and rivalry possible. To undo it can be very costly. Therefore, it is better to be careful at the start. There is huge number of S&T institutions in India and Brazil, which are not well linked leading to inevitable duplication of efforts and smaller budgets.
- Basic sciences or basic research have a long gestation period, therefore, developing countries should keep them to the minimum necessity. But technical and engineering skills have immediate relevance to the industrial technology development. Thus, they are more sustainable because they are directly active in the productive sector. In this respect, the tigers have done it right.
- National consensus on major S&T policies and projects increases sustainability. Different interested groups may pull in different directions. You need their backing. Otherwise the aggrieved parties will frustrate implementation. The very size of India and Brazil makes it difficult to have national consensus on any big national investment project and also time consuming. The tigers have an advantage because of their smaller sizes and strong governments. They have managed to have consensus on important national S&T projects by bringing aboard all the major stakeholders.

- Government's expenditure should be always within the manageable limit. Otherwise financial crisis leads to austerity measures starving, in the process, deserving science and technology projects. This was particularly true of Brazil. India has incredibility managed to keep a high expenditure, level relative to its economy, on R&D but the return has not been exiting.

2. Flexibility and transferability

The S&T environment is rapidly changing. Keeping up with continuous change is a must. Scientific discovery or technological innovation in one area can have an impact to the other areas. Therefore, ability to adapt quickly and transferability of skills and knowledge should be always kept into the equation.

- When old techno-economic paradigm changes and a new one are coming, the old S&T institutes may become less relevant. This is the time when these institutions should adapt or face death. Old cows should be allowed to die peacefully or face the consequence of feeding them without getting back anything in return.
- Political ideologies should not guide the development of S&T because makes one insensitive to actual market demands and, thus, it is less flexible to change.

3. Quality

Quality is a relative term. The best measure is relative to immediate competitors. Here, we are talking of policies, institutions and human resources. Their mere presence does not guarantee success. Therefore, the culture of quality should be nurtured early on in the process of technological development of developing countries.

- Not only number of skilled workforce but also quality of skill is crucial to technological development.
- Not the number of institutes but the quality and the co-operation among themselves is crucial.
- Polices should not be only a declaration of intentions but must be implemented. It is not the type of polices that matter most, but the quality of implementation.
- It is not the presence or absence of TNCs that help or hinder the technological development but the quality of relationship between local private enterprises, the TNCs and the government that matters most.
- It is not whether a government should intervene or leave everything to market forces. It is the quality of intervention that matters most.

4. Priority

Are all S&T equally important to rapid economic development of the developing countries?

- Some are more important than others depending on time and circumstances.
- IT, at the present time, is the most pervasive technology that can contribute to improve to the productivity of all sectors.

5. Result

S&T as the basis of economic development of a developing country can be best measured by the contribution it makes to that particular country in the international competitiveness.

- Excellent institutes in isolation cannot help in achieving international competitiveness.
- Highly skilled workforce with poor management cannot bring international competitiveness.

- Even market forces alone, in the developing countries, cannot get result without government support, particularly in the high-tech industries.
- Too much government intervention and control hampers the market operation and the rent seeking behaviour abounds to the detriment of competitiveness.

Particular lessons on IT

Institution level efforts to invest in and manage information technology have to draw heavily on information from external sources, including suppliers and consultants, and inputs from technology institutions, and from overseas. Even large firms find it too costly to collect information on alternative information technologies, sources and prices. This is particularly the case for imported and fast changing technologies. The most successful countries like Korea and Japan have helped importers and adopters of IT by developing specialised agencies or programs for information acquisition and dissemination.

The problems of inadequate availability of reliable information on technology choices, of biased information from suppliers, and of information asymmetries between multinational suppliers and local users are pervasive in information technology and most acute among small and medium-size enterprises. Therefore, developing countries need to take appropriate actions with regard to IT diffusion. The following are suggested based on the lessons from the NIEs.

The main lessons about policies and programs for IT diffusion in industry and services are as follows:

- The policy context is crucial because it defines and co-ordinates the role and activities of the major players in the national innovation system of a country. It includes trade, industrial, technology and competition policies - as well as IT-specific policies to improve access to, and to create markets for information technology products and services (as though public procurement).
- Government can lead or play a catalytic role in developing IT policies, manpower, computerising public administration and financial services, diffusing IT application among small and medium-size enterprises, promoting software and computer services, mobilising local and global information resources, and inducing collaboration among public, private, academic, and foreign agencies.
- Technology parks and incubator facilities that provide shared infrastructure and support services are important for clustering and networking, and for providing key services for small and medium software and information services firms.
- Demonstration projects can be extremely persuasive in addressing the entrepreneur and technologist's scepticism. These projects should involve real users in real work settings, not showpieces in research institutes.
- Collaboration among suppliers and users is often necessary to match supply with demand - and networks, clearing-houses, intermediaries, private associations, and other channels are vital to effective adoption and diffusion of new information technologies.
- Consulting and extension services often subsidised for early adopters of IT, are especially important for small and medium-size enterprises. IT adoption often requires changes in core business processes, so the risks go beyond the investment costs for IT. For small and medium-size enterprises, diffusion programs typically use cost sharing to reduce risk and induce users to take manageable risks.
- The business problems and technological capabilities of users should be well understood to design diffusion programs. Potential users need to see the business rationale for adopting information technology and the ways it can improve their competitiveness.

- Firms need complementary human resource development programs for adopting and managing information technology.
- Public agencies should rely as much as possible on contracting out systems development and computer support services to the private sector, in view of the fast pace of change in IT and the limitations on the civil service to develop and maintain a large and responsive in-house information systems organisation.
- The lack of any central oversight and a critical mass of in-house expertise in the public sector often hinder the sharing of information, common applications, bulk procurement, and lessons of experience, and the development of information standards and protocols and common information infrastructures. Therefore, appropriate measures need to be taken to avoid these kinds of problems.

PART II

Science and technology in SSA

SSA countries are traversing very cloudy and turbulent times. They need a new breed of leadership with strong vision and feeling of the promised land of peace, stability and work.

In Part II we are continuing what we started in Part I. We are still answering the first study question but in SSA countries. Therefore, we are trying to answer the question: What is the state of S&T policy and management in SSA countries? What is the state of their IT? Of course, the state of S&T and its integration with the socio-economic development is the major concern. The fact that these countries are still heavily dependent on primary goods production and export shows that industrialisation has still to mature in Africa. industrial technology is at rudimentary stage. And as whole this part of the world is known as the least developed and technologically backward. What went wrong? The next chapters will shed light on this question.

The structures of the following chapters are the same as in Part I. It starts from a broad S&T policy analysis and implementation to IT policies and implementation. International environmental factors, policies, institutions, human capital formation and the melting-pot where the integration of S&T or IT policies with economic development plans are assessed. Finally the lessons derived are summarised.

7

7. S&T in Sub-Saharan African Countries

7.1 Introduction

The following three chapters deal with the SSA countries. Similar to what we have done in Part I about the NIEs, we will continue in this part also to look separately into S&T in general, IT in particular and concluding remarks for the SSA countries. It is clear that SSA countries are way back by every measure from the NIEs. The question is whether S&T have matured to support a healthy socio-economic development in SSA countries or not. Let us find out if the poor economic performance is linked to the poor S&T base available in these countries.

The section has been organised in a way suitable to answer the question 'Where do the SSA countries stand with regard to S&T?' Therefore, the environmental context in which S&T is evolving in these countries, the institutional capabilities they have been able to create, the human capital formation achieved and the consequent learning and international competitiveness will be discussed.

SSA countries include all but the Northern African countries. This research excludes also South Africa because it is a special case with less SSA characteristics. Most of these countries have the lowest per capita income in the world, which ranges between US$90 of Mozambique and US$750 of Zimbabwe in the 37 low-income groups of countries. While among the middle-income group the range goes from US$1,050 of Equatorial Guinea to US$6,880 of the small island of Seychelles. The countries at the top of the per capita list in SSA countries are: Botswana, Cape Verde, Djibouti, Equatorial Guinea, Gabon, Mauritius, Mayotte, Namibia, and Seychelles. That of Seychelles, Gabon and Mauritius is higher than that of South Africa (US$3,400). But all of these countries are small with the exception of Namibia, which is big in territorial size (823,000sq km) and small population of 2 million people. For example, Seychelles has only 78,000 people and the remaining all are below 1.5 million people and territorial size below 28,000sq km (Table 7.1).

Closer look into the GDP growth of these 37 low-income countries shows that during the 1990-91 period only 11 countries grew relative to their respective growth during the previous decade, 1980-90. Particularly three countries, Mozambique, Uganda and Lesotho showed the fastest growth. Mozambique's GDP during the previous decade was growing at an average of 1.8 percent per year while in the 1990s grew at an average of 6.9 percent. Uganda's growth was more than double the previous decade, from an average 3.1 during the 1980s to 7.2 percent during the 1990s. That of Lesotho grew at slightly less than double of that of previous decade, from an average of 4.3 during the 1980s to 7.6 during the 1990s. Ethiopia also grew during the 1990s at double of that of 1980s, from an average of 2.3 to 4.5 percent, but it was far below the average growth shown by the previous three. The others that showed improvement in their GDP growth during the 1990s are Benin (from 3.2-4.5%), Ghana (3.0-4.3%), Malawi (2.3-3.6%),Mali (2.9-3.3%), Mauritania (1.1-4.3%), Niger (0.1- I.5%), and Nigeria (1.2 – 2.7%). Eritrea's average GDP growth is estimated to be 6.5% or 7% during 1993-97 but there is no base of comparison in the previous decade; the country was not independent yet.

Table 7.1: Economic performance of the SSA countries in 1980s and 1990s

Countries	Population in millions 1997	GNP in billions 1997	GNP per capita	Gross domestic investments 1990-97	Growth of the econ.; annual % growth of value added For 1980-90 and 1990-97				
					GDP	Agriculture	Industry	Services	Exports
Low-income countries									
Angola	11	3.8	J40	8.4	0.7	-5.7	5.1	-3.0	5.6
Benin	6	2.2	380	2.3	4.5	5.1 5.1	4.1	4.1	-3.1 3.3
Burkina Faso	11	2.6	240	3.2	3.3	4.1	1.9	2.7	-0.4 -2.4
Burundi	7	1.2	180	-10.4	-3.7	-2.8	-8.0	-3.0	-3.2
Cameroun	14	9.1	650	-1.7	0.1	3.2	-3.8	-0.5	4.7
Central Africa	3	1.1	320	-0.	1.2	1.5	0.1	0.7	-1.2 0.6
Chad	7	1.6	240	-	1.8	5.4	0.0	-0.5	3.7
Comoros	0.518	0.0022	400	-	-	- -	-	-	-
Congo, D.R.	47	5.1	110	-5.0	-6.6	3.0	-15.9	1.2 -17.4	9.6 -8.8
Congo, Rep.	3	1.8	660	-0.6	0.7	0.9	0.6	0.5	6.3
Cote'd'Ivoire	15	10.2	690	14.4	3.0	2.6	4.2	2.8	1.9 5.0
Eritrea	3.8	0.801	210	-	-	-	-	-	-
Ethiopia	60	6.5	110	21.4	4.5	3.0	4.1	6.9	8.6
Gambia	1.18	0.409	350	-	5.2	-	-	-	-
Ghana	18	6.6	370	4.7	4.3	2.7	4.3	6.1	7.1
Guinea-Bissau	1	0.3	240	-6.5	3.8	5.5	2.7	1.4	-1.7 14.9
Kenya	28	9.3	330	3.5	2.0	0.8	2.0	3.6	2.3
Lesotho	2	1.4	670	12.7	7.6	4.0	11.8	6.0	9.9
Liberia	2.894	-	-	-	-	-	-	-	-
Madagascar	14	3.6	250	-0.9	0.8	1.7	1.1	1.0	-1.7 4.0
Malawi	10	2.3	220	-7.9	3.6	4.7	1.9	2.7	3.3
Mali	10	2.7	260	15.1	3.3	3.4	7.0	2.1 1.8	6.4
Mauritania	2	1.1	450	4.0	4.3	5.0	3.7	4.0	0.1
Mozambique	19	1.7	90	3.6	6.9	4.6	-5,2 2.3	10.4	9.3
Niger	10	2.0	200	3.0	1.5	2.3	-1.7 1.3	-0.3 0.9	-2.9 0.8
Nigeria	118	30.7	260	0.7	2.7	2.6	-1.1 0.5	4.8	-0.3 3.6
Rwanda	8	1.7	210	10.6	-6.3	-5.8	-11	-6.9	3.4 -15.3
Sao Tome & Principe	0.138	0.038	270	-	-	-	-	-	-
Senegal	9	4.9	550	6.9	3.1 2.4	2.2	4.1 3.7	2.1	1.0
Sierra Leone	5	0.9	200	-12.8	-3.3	-1.5	1.7 -6.4	-2.7 -3.9	0.2 -18.4
Somalia	10	-	-	-	-	-	-	-	-
Sudan	27.86	7.801	280	-	6.4	-	-	-	-
Tanzania	31	6.6	210	-	-	-	-	-	-
Togo	4	1.4	330	-4.4	2.2	14.7	2.0	-0.3 -20.6	1.3
Uganda	20	6.6	320	9.9	7.2	3.8	13.0	8.5	17
Zambia	9	3.6	380	-	-0.5	-	-	-	-
Zimbabwe	11	8.6	750	5.8	3.4 2.0	3.1 3.8	3.2 -0.8	3.0 2.7	10
Lower-middle-income									
Cape Verde	0.399	0.436	1,090	-	-	-	-	-	-
Djibouti	0.636	-	-	-	23.0	-	-	-	-
Equatorial-Guinea	0.421	0.444	1,050	-	-	-	-	-	-
Namibia	2	3.6	2,220	4.1	- 106.6	4.3	2.9	-0.2 4.2	4.4
Swaziland	0.952	1.369	1,440	-	4.1 2.6	- -	-	-	-
Upper-middle-income									
Botswana	1.51	4.922	3,260	-	7.8	- -	-	-	-
Gabon	1	4.9	4,230	1.2	2.6	2.3	2.7	-0.3 3.3	-
Mauritius	1	4.3	3,800	0.4	5.1	0.3	5.5	6.3	-
Mayotte	0.108	-	-	-	-	-	-	-	-
Seychelles	0.078	0.537	6880	-	2.4	-	-	-	-
S. Africa	38	130.2	3,400	13.0	1.2 1.5	2.9 2.5	0 0.8	2.3 1.8	-

Source: World Bank, World Development Report, 1998/99.

From the remaining, 18 countries showed decline in their GDP growth in 1990-97 relative to that of 1980-90. Five countries in particular showed negative GDP growth during the 1990s: Burundi, Democratic Republic of Congo, Rwanda, Sierra Leone and Zambia. Kenya's GDP growth during 1990-97 was 2.0% per year, which was by half less than that of 1980-90 growth of 4.2% per year.

Table 7.2: Value of exports from world, less-developed countries (LDCs), SSA, and 1950-90.

Region	Year				
	1950	1960	1970	1980	1990
World (billion)	60.7	129.1	315.1	2,002.0	3,415.3
LDCs (billion	18.9	28.3	57.9	573.3	738.0
SSA (billions $)	2.0	3.8	8.0	49.4	36.8
Share of LDCs as % of world exports	31.1	21.9	18.4	28.6	21.6
Share of SSA as % of world exports	3.3	2.9	2.5	2.5	1.1
Share of SSA as % of LDCs exports	10.6	13.4	13.8	8.6	5.0

Source: *UNICTAD 1979, 1989 and 1991, table 1.1, elaborated by Simon et al. (1995) and quoted in Castells (1998).*

It is not difficult to show that the SSA countries are at the margin of the global economy. The world export shire of SSA decreased even from the 3% that it used to be in 1950 to 7.7% in 1990 (Table 1.2).It was not able to maintain its share as per cent of that of LDCs exports, which decreased from 10.6% in 1950 to 5.0% in 1990. This is a very poor performance by all measures. There are many reasons for it. The major factors are explored in later sections.

Table 7.3: Structure of export (percentage share), 1990.

Region	Fuels minerals and metals	Other primary commodities	Machinery and transport equipment	Other manufacturing	Textile and clothing
SSA	63	29	1	7	1
East Asia and Pacific	13	18	22	47	19
South Asia	6	24	5	65	33
Europe	9	16	27	47	16
Middle East % North Africa	75	12	1	15	4
Latin America & Caribbean	38	29	11	21	3
Low & Middle-income countries	31	20	15	35	12
Low-income countries	27	20	9	45	21

Source: World Bank (1992) and quoted in Castells (1998)

Table 7.4: S&T development indicators of SSA

Countries	Public exp, on Educ. As % of GNP		Net enrolment as a % of relevant age groups				Scientists Engineers in R%D per million	High tech experts % mfg export	No. Of patent applications filed in 1995	
			Primary		Secondary					
	1980	1995	1980	1995	1980	1995	1981-95	1996	Res.	Non-Res.
Low-income countries										
Angola	-	-	-	-	-	-	-	-	-	-
Benin	-	3.1	-	59	-	-	177	-	-	-
Burkina Faso	2.6	3.6	-	31	-	7	-	-	-	-
Burundi	-	2.8	20	52	-	5	32	-	-	-
Cameroun	3.2	-	-	-	15	-	-	3	-	-
Central Africa	-	-	56	-		-	55	0	-	-
Chad	-	2.2	-	-		-	-	-	-	-
Comoros	-	-	-	-		-	-	-	-	-
Congo, D.R.	2.6	-	-	61		23	-	-	3	15
Congo, Rep.	7.0	5.9	96	-		-	461	12	-	-
Cote'd'Ivoire	7.2	-	-	-		-	-	-	-	-
Eritrea	-	-	-	-		-	-	-	-	-
Ethiopia	-	4.7	-	24		-	-	-	-	-
Gambia	-	-	-	-		-	-	-	-	-
Ghana	3.1	-	-	-		-	-	-	-	42
Guinea-Bissau	-	-	47	-	3	-	-	-	-	-
Kenya	6.8	7.4	91	-	-	-	-	-	-	28,728
Lesotho	5.1	5.9	66	65	13	16	-	-	8	2,608
Liberia	-	-	-	-	-	-	-	-	-	-
Madagascar	4.4	-	-	-	-	-	22	3	21	15,802
Malawi	3.4	5.7	43	100	-	66	-	3	5	28,868
Mali	3.8	2.2	20	25	-	-	-	-	-	-
Mauritania	-	5.0	-	60	-	-	-	-	-	-
Mozambique	4.4	-	36	40	-	6	-	5	-	-
Niger	3.1	-	21	-	4	-	-	-	-	-
Nigeria	6.4	-	-	-	-	-	15	-	-	-
Rwanda	2.7	-	59	76	-	8	12	-	-	-
Sao Tome & Principe	-	-	-	-	-	-	-	-	-	-
Senegal	-	3.6	37	54	-	-	342	55	-	-
Sierra Leone	3.8	-	-	-	-	-	-	-	-	5
Somalia	-	-	-	-	-	-	-	-	-	-
Sudan	-	-	-	-	-	-	-	-	-	-
Tanzania	4.4	-	68	48	-	-	-	-	-	-
Togo	5.6	5.6	-	85	-	-	-	-	-	-
Uganda	1.2	-	39	-	-	-	-	-		20,840
Zambia	4.5	1.8	77	77	-	16	-	-	4	90
Zimbabwe	6.6	8.5	-	-	-	-	-	5	56	177
Lower-middle-income										
Cape Verde	-	-	-	-	-	-	-	-	-	-
Djibouti	-	-	-	-	-	-	-	-	-	-
Equatorial-Guinea	-	-	-	-	-	-	-	-	-	-
Namibia	1.5	9.4	-	92	-	36	-	-	-	-
Swaziland	-	-	-	-	-	-	-	-	-	-
Upper-middle income										
Botswana	--	-	-	-	-	-	-	-	-	-
Gabon	2.-7	-	-	-	-	-	189	32	-	-
Mauritius	5.3	4.3	79	96	-	-	361	1	3	4
Mayotte	-	-	-	-	-	-	-	-	-	-
Seychelles	-	-	-	-	-	-	-	-	-	-
S. Africa	-	6.8	-	96	-	52	-	-	5,549	5,501

Source: World Bank, *World Development Report, 1998/99.*

These evidences seem to point to one thing. The gap between the developed countries and that of SSA countries is increasing at increasing pace in the last three decades. These are the decades when 'knowledge' is increasingly emerging as the power behind the economic performance of countries. II has played a significant role in this knowledge generation race and increased its speed. All of this is happening at a time when the SSA countries are not even aware of it or seem not to have the necessary resources to do something about it. This research is arguing that if SSA countries do not take action before it is too late, their fate may be catastrophic.

A closer look at the structure of SSA countries' exports show that 92% is made up of primary products, an economic structure that did not change much from the colonial period four decades ago (Table 7.3). Of this 63% is made up of fuel minerals and metals, which is basically the extractive industry dominated by the multinationals with insignificant spin off effect on the rest of the economy.

It is very clear from Table 7.4 that SSA countries have insignificant S&T capability. AII the indicators give us a dismal picture. This research, as it has done in the previous two chapters with the NIEs, will show that increased international competitiveness is not possible by following the traditional way of confining oneself in the supply of primary products only but by mastering the necessary knowledge (science and technology). It will show that the SSA countries are losing ground with every passing year.

7.2 Environmental context

In a recent World Development Report by Word Bank (1998/99) 37 of SSA countries are classified as lowest income group which is about 70% of all African countries. Their economics are the least developed in the world and heavily dependent on aid for development. Their political environment is that of instability, civil wars and, recently, regional wars are on the brink of erupting ones again in the region of the Great Lakes and the Horn of Africa. The legacy of colonialism is still visible.

Basically SSA countries have two faces, the modern and the traditional. The modern is usually found in the urban centres and the traditional in the rural areas. Mamadou Dia (1996:3) has a point in arguing that most African countries found themselves saddled with a hybrid and disconnected institutional system. The formal or modern institutions transplanted from outside, mostly as a result of the colonial heritage had been superimposed upon indigenous, informal institutions characterising the civil society and reflecting its culture and tradition. The result was institutional disconnect with more far-reaching ramifications than in Latin America and Asia, which also underwent the colonial experience. African countries experienced a 'disconnect' between the state and the civil society, between the formal and informal private sectors, and between the corporate and societal culture. Many African rural communities and nomads are completely cut off from the mainstream economic and social life of the country.

The colonial legacy is nowhere more evident than in the fact that SSA countries are made as the suppliers of prime products to factories of colonial masters and the extension of their own markets. This is true even today. Most of the SSA countries depend on the export of few primary products. If we see the World Bank report (1989), between 1965 and 1987 the proportion of exports accounted for by primary products rose from 92 to 94 percent in low income African countries while falling slightly from 95 to 90 percent in middle-income countries. This was the result of a colonial economy that destroyed the intra-African trading systems, which were not Europe-oriented, and the capture of their resources (Young, 1986, p.28). But continued specialisation on primary products did not give comparative advantage to the African economies. Primary product prices are subject to more severe fluctuations than manufactures which gives rise to special difficulties for economic management (See Macbean, 1966; Ranis and Fei, 1988). Specialisation on primary product offers less in the way of economies of scale and learning than manufactured exports. Moreover, the large share of world exports of African Economies in certain commodities, together with low price elasticity, mean that increases in output result is less than proportionate increases in earning (Stewart, Lall, and Wangwe, 1992).

Following the dismal performance in the process of industrialisation, MF and the World Bank pressed for structural adjustment of the African economics. The Bank's structural adjustment policies have also contributed to the exacerbation of the situation by focusing on expansion of the traditional primary export production. Instead of doing something concrete to alleviate the foreign debt burden, this is crippling the poor countries’ economies in Africa. The Bank has been preaching austerity measures beyond the capacity of most African countries. These coupled with mismanagement of the economy and corruption in the government and the recurrent drought has thrown millions of Africans into extreme poverty, which has become a way of life.

The political situation is even worse. Stable governments are rare. Too many military coups, civil war and corrupt dictators. Democracy has yet to grow. People are increasingly losing confidence in their governments. Foreign investors find Africa still full of political risk with the exception of few. Peace and political stability plays a determinant role in economic development. Countries enjoying the high economic growth rates are invariably those with strong leadership and relatively smooth successions and virtual freedom from pending civil upheavals (Whitaker, 1986). Exclusionary practices that could keep some from participating in administrative, policy, and economic decision-making are therefore very likely to sow the seeds of institutional and political instability. There is an enormous need for leadership commitment to a more inclusive institutional formula behind which entire nations can rally (Dia, p. 250). Moreover, 'the channelling of virtually all lager investments through government, and complex licensing and allocation of foreign exchange often create rewards for loyal allies and windfalls for the government officials who administer them' (Whitaker, ibid.). Most of the time this leads to the corrupt government systems observed in Africa. Arthur Lewis (1965) already had said that African leaders demand to be treated like Egyptian pharaohs and to be a minister is to have a lifetime's chance to make a fortune. The challenge is, therefore, the creation of stable, transparent, accountable and more efficient government civil services.

The impact of the 'cold war' on the Sub-Saharan African countries has been tremendous. At a time when the two camps were very busy enlarging their zone of influence, Africa was again divided among the West and the Soviet Block in a new subtle way of new colonisation of ideology. Access to economic aid was very much dependent on your affiliation. At the times of fighting for political freedom, socialism was trendy in many parts of Africa. Any country wanting to attempt a third way was considered a suspect and was increasingly isolated. The 'non-aligned' movement of countries was trying to create a new forum but it was not an influential movement.

The SSA countries operate now in an international trade increasingly unfavourable to them. Currently the big and powerful developed countries dominate the international trade. A clear realignment in the international markets is taking place. In the foreseeable future the international trade will be dominated by the three trading blocks: North American trade block, the European Union trade block, and Asian trading block. The black continent is nowhere. The scientific and technological backwardness is there as the biggest stabling block to this continent to take its right place in the international trade and economy.

The SSA countries did attempt to redress the scientific and technological deficiency in the early 1960. The time was when most of them got their freedom from the colonial rule. It was clear that the strategies followed in the past had made the.se countries completely dependent on their previous masters. Something had to be done. International agencies tried to help in the development of S&T development in Africa and the first conference under the auspices of UNESCO was held. It is considered a landmark. It was in Lagos, Nigeria, in 1964. The conference was about Organisation of Research Training in Africa in relation to the study, conservation and utilisation of natural resources. The conference adopted the Lagos Plan for Scientific Research and Training in Africa. The goal was to assist African governments in taking appropriate steps for the advancement of scientific research with the help of international co-operation.

In 1967 in Yaoundé, Cameroon, was held the Symposium on Science Policy and Research Administration in Africa. The purpose of the Symposium was to evaluate the situation regarding science policy and research organisation in the light of Lagos Conference and to analyse and forecast national science policy situation according to geographical, political and economic realities.

In 1970 in Addis Ababa, Ethiopia, from 5-16 October a Regional Symposium on the Utilisation of Science and Technology for Development in Africa was held. The Symposium trade 43 recommendations relating to policy-making and planning in S&T; human resources for scientific and technical development; infrastructure for S&T; national resources survey; research and development; industrial research and development; and regional co-operation in S&T.

Castafrica I was held in Dakar, Senegal, from 2l-30 January 19'74.The major topics were: trends of S&T policies in the countries of Africa, new technologies and the possibilities for their development and application in Africa, scientific and technological co-operation in Africa. This conference gave to participant countries the means and opportunity to exchange information about their respective S&T policies; and promoted scientific and technological research and international research co-operation. Thirteen years later, the CASTAFRICA II was held in Arusha (Tanzania) from 6 to 15 July 1987. It debated and evaluated the progress of S&T since CASTAFRICA I; it debated also science and technology policies for rural and industrial development; and the bases for scientific and technological development (education and training, scientific and technological research, science and technology services). It strongly appealed to the Governments of African Member States to define and implement clear national S&T policies and allocate the resources necessary to strengthen their scientific and technological capabilities. Using S&T for the judicious exploitation of the natural resources of the continent was considered the only way to improve the standards of living of the peoples of Africa (UNESCO, 1988).

If one sees the concrete actions taken by the African countries in terms of S&T policy organs established, some change has been made. For example at the time of CASTAFRICA I only Algeria, Egypt, Gabon, Tunisia and Ivory Coast had ministries explicitly assigned the responsibility to formulate a national S&T policy while other twelve countries had established some kind of S&T or Research .councils. Reports show that the number of S&T policy organs has increased significantly since CASTAFRICA I. In 1979 such organs increased from 69 to 157, i.e. 88 new bodies were created. The number of ministries increased from 5 to 18 for natural science research; from 2 to 25 for medical research: from 4 to 21 for industrial research, from 7 to 25 for environmental research (Forje, 1987). In 1991, With exception of Cameroon, Congo (Rep.), Cote d' Ivoire, Ghana, Kenya, Nigeria, and Senegal that had an adequately functioning Science & Technology bodies, all the rest of SSA had fairly stable or poorly organised S&T bodies (UNECA, 1991). Institutional development has mainly benefited agricultural research and research in the economic and social sciences. Capabilities in the engineering and technological sciences in the overwhelming majority of African countries have changed little since CASTAFRICA I (UNESCO, 1988, p. 175).

With regard to manpower development, African countries have not been able to achieve the targets they set in GASTAFRICA I by 1980. The exception is Egypt. Nonetheless, the number of scientists and engineers more than doubled from 1970 to 1980, i.e. from 18,589 to 40,812 (UNESCO, 1986, SC-87/CASTAFRICA II/REF 3, p.24). The number of students in higher education rose from 142,000 in 1960 to 1,169,000 in 1980.

The resource allocation decided by Dakar conference was at least 1% of GNP by 1980. But 'the average percentage of GNP allocated by African countries falls within the range of 0.2% to 0.5%. Some African countries have even noted regressive trends in GNP allocations (See Forje, in A. Ahmad (ed.), 1993).

UNESCO launched in 1989 the Priority Africa programme along the lines of emphasis outlined in the Lagos Plan of Action for the Development of Africa (1980-2000). In pursuance of these aims, UNESCO organised in 1995 a Conference titled 'Audience Africa' designed to identify priorities for Africa development, which produced a series of recommendations on capacity building in Africa. In order to help in the capacity building, UNESCO's Intergovernmental Information Programme (IIP) has introduced informatics into the education system in selected African countries. IIP plan is to extend its activities under Regional Informatics Network for Africa (RINAF) to include a growing number of African institutions to further consolidate the joint activities of African scientists in education and administration. Moreover, UNESCO is promoting the development of a Satellite University of Science and Technology (SUST), an inter-university network to broaden global education exchange Via Satellite broadcasting (hup://www bellanet org/partners/aisi/policy/entry,/Nigeria htm).

In the last few decades, the rapid industrial expansion has been associated with a rising standard of living in Asia leaving SSA further behind. We cannot attribute this dismal performance in SSA countries to the colonial legacy or to flaws in the post-colonial African ruling class. Rather, some patterns of state behaviour and structure that arose out of the character of the colonial state and the ways in which the post-colonial state adapted its colonial legacy contribute toward an understanding of the dimensions of the present crisis (Young, 1986, p.26). Furthermore, it can also be attributed to the poverty of 'knowledge' and lack of political will and determination. It is from this context that we need to look for a window of opportunity to exploit a good S&T (in its broader sense) policy to initiate an adequate industrial technology in order to escape from the vicious circle of poverty. Particularly IT can play a major role in acquiring information and knowledge and disseminate it where required. Not only that, it could be a valuable tool in the way we produce and sell goods and services. At the end, that would help the SSA countries to escape the increasing marginalisation from the global economy. But this is simpler said than done. The following section will show how complex and painful can be to grow and mature as internationally competitive economy.

7.3 S&T policy

The S&T in relation to economic development in SSA is an area least researched. The literature shows lack of systematic coverage and what is available is fragmented and anecdotal. The aim of these two chapters, therefore, is to use the available material and understand the factors underlying of the vicious circle in which these countries are found. Similar structure to that used in Part I of the research with the NIEs is followed as much as possible.

Vision and goals

SSA countries departed with a great vision at the time of their independence from the colonial powers. This vision was one of a quick industrialisation. The la.st four decades dismal performance has shaken that vision. The confidence is very low. At times, in extreme cases, some think that there is no hope for Africa because it is increasingly marginalised from the global economy. But African people can never afford to lose that vision of a continent of peace, stability, and prosperity. It happened in South Africa when the situation seemed hopeless and, now, it seems Nigeria will be next to see some glimpse of hope for manmade disasters, which is mostly the case of African countries, can be undone. Therefore, the vision is still the same: making Africa a continent where people can work in peace and harmony to develop all their human capital resources to exploit properly its rich natural resources. It is to gain a respected place within the international community and gain a fair share of the global economy.

The Lagos Plan of Action, say that the long-run objectives of the SSA countries is (i) the alleviation of mass poverty and improvement in the standard of living of the people; (ii) self-sustained development; (iii) national and regional self-reliance. Stewart, Lall and Wangwe (1992) call it 'sustainable economic growth combined with social justice'. But what could be the role of S&T to bring these socio-economic objectives into reality? The two have never been integrated consciously. To avoid this, trends and priority areas of R&D and related activities have been discussed in meetings of experts from the region, for example meetings organised by UNESCO as a follow up of CASTAFRICA I in Nairobi in 1983 and in Dakar in 1985. The identified priorities were achievement of food self-sufficiency; combat desertification, rational development and exploitation of rivers, lakes and oceans; exploitation and valorisation of mineral resources; valorisation and dissemination of research results; use of national languages for the popularisation of science; enhancement of the role of social sciences in the assimilation of technology and innovation by people at large; encouragement of appropriate technologies and their diffusion and commercialisation; and the selection, assimilation, and adaptation of imported technologies (UNESCO, 1988, p189-90).

SSA countries governments are, in general, fully aware of the important role that S&T can play in the socio-economic development of their countries but very few have a clearly defined national S&T policy aimed at ensuring the systematic use to achieve development plans. On the other hand there are few with relatively developed science and technology policy-making bodies (Senegal, Cote d'Ivoire, Nigeria, Ghana, Kenya, Cameroon and Congo Republic) (UNESCO, 1986, 1987). In the national S&T policy of these countries we encounter the following S&T objectives:

- -to determine the overall orientation of national S&T policy (provide policy advise to the government, determine technological priorities appropriate for supporting the socio-economic development, to prepare plans and budgets, and to develop endogenous science and technology and less dependent S&T capability);
- -to build and manage the national science and technology system (invest in S&T infrastructure, to create effective research co-ordination system, to develop scientific and technological manpower, to control brain drain, to encourage the scientific and technological development in all sectors with adequate resources, to develop research institutes where necessary, to strengthen regional and international scientific and technological co-operation);
- -to execute R&D and provide S&T services (to build up national documentation and information centre for dissemination of scientific and technological research results, establishing patenting system, provide local consulting services in technology transfers, promote S& T awareness within the society at large,).

In general, priority was given to agriculture, food processing and storage, afforestation and desertification control, traditional medicine, communicable disease control, energy, mineral resources, technology assessment and the appropriate technologies, administrative and social sciences, instrumentation and information services, and the popularisation of science. African countries have to catch-up in S&T if they want to really give a better living standard to their people. In a world that is changing very fast, the danger of being left out is very high. In fact, the information technology revolution has increased the power of mankind to generate knowledge. But Africa does not have this power yet. This means that the more time is lost in catching-up the more will be the gap between the developed world and the less developed countries. That may mean 'being condemned for ever for a life of poverty without hope'. Therefore, Africans need to master all the 'knowledge' they need to break the circle of poverty in which they are trapped. To learn as an individual, to learn as a community, to learn as a country and to learn as a region bound by this one 'goal' requires a strong leadership, people with a clear vision and determination that can inspire confidence and enthusiasm to their people. This is the key to every development strategy. But how do we get or make such 'leaders'? May be Africa needs to learn how to 'uncover' its leaders as well.

Science & technology policy

It is rare to find in SSA a country with a macroeconomic policy well integrated to and assisted by S&T policies, including that of developing the required highly skilled manpower to achieve economic and social development. Polices were frequently changing, particularly during the cold war time, as a result of countries going back and forth from the capitalist to the socialist camps. Other times, apparently good policies were rendered ineffective because what is said and done was different, i.e. policies were only paper work or rendered so by weak, corrupt and ineffective governments. At other times it was the political instability in these countries the culprit. Anyway, the origin and development of S&T in SSA countries is linked to the colonial past. After independence many of these countries sought the help from UNESCO and other UN agencies in the field of S&T policy formulation. UNESCO did organise a number of international meetings to increase awareness and to promote S&T for the socio-economic development in Africa. The countries we have mentioned above with functioning S&T bodies have received technical assistance at one time or another from LINESCO and other UN or other international development agencies. But a lot remains to be done.

Recently, a professor of Addis Ababa University was lamenting the disconnect that exists between the research policy, S&T policy and development policies. In his own words, 'A .sound research policy, correctly articulated with the country's S&T and development policy as a whole, is needed if the general objectives of the Addis Ababa University are to be promoted. A key component of this policy is obviously scientific, as it will be impossible to respond to our countries needs without the wise use of science in developing the biological, human, social and economic resources of the country' (E.Bekele, 1996). He suggested that the academic individualism prevalent in his university be replaced by integrated systems approach where multidisciplinary research is encouraged, and the professional separation of technologists from economists and of training from research, that is commonplace, be discouraged. Given that this is a typical problem of SSA countries, the suggestion is valid for all to boost scientific and technological research for social and economic development of their countries. Now we will first go over the economic and industrial policies in SSA countries, as these give the clues of the implicit S&T policies, and then, we will be back to discuss the limited explicit S&T policies.

To understand how S&T policy can contribute towards the successful achievement of socioeconomic development objectives, we need to explore the experience of SSA countries' performance first. There are three types of explanations suggested in the literature about the failure of the economic performance in SSA countries. One is the inward oriented, heavily protectionist trade policies and the interventionist price-distorted industrial policies adopted (Berg Report) which led to adjustment packages by the Bank. The second is the deteriorating terms of trade and the worsening debt situation that have caused an import-drought which has starved industry of essential imports and consequently brought industrial development to a half (external shocks). The third is the weak industrial capability and deficient institutions. Now, let us give some brief explanation of the conflicting analysis made of the dismal performance of the SSA countries.

In the ongoing debate of SSA economic performance, S&T has never been a big issue. One of the main reasons is that SSA countries are at the initial stage of industrialisation where simple labour-intensive technologies are more relevant. The same was true of the East Asian Tigers three-four decades when they were starting their industrialisation process. Usually S&T are associated with high-tech or R&D at the technology frontier and as such are considered less relevant to SSA context. But in reality, even the so-called simple technologies need institutional support to become effective. We will witness again and again that SSA countries failed to establish a working industrial structure based on mature technologies through sustainable technology transfer mechanisms. The lower labour cost should have given them competitive advantage. But effort to increase the skills of the labour force to increase labour productivity and the creation of able management cadres is even missing. All add up to make a very sad picture. SSA countries, therefore, need at the very heart of their policy debate the skills of their people and their productivity, the support to relevant technology transfer and management, and entrepreneur culture development, which are all elements of S&T policy debate. Let us have a quick view of the ongoing debates and we will try to relate it to S&T policy and management later on.

Most SSA countries were engaged in a massive programme of state-sponsored industrialisation after independence. As a result, the industrial sector grew on average by 8 percent per annum during the 1960s and accounted for 15 per cent of the region's GDP. For a variety of reasons, however, such a rapid expansion could not be sustained, and a process of de-industrialisation started. One of the major factors is the 'development-related debt' which ultimately resulted in the 'debt crisis' of SSA. We do agree with those writers that have concluded that when the expected growth and development did not materialise and, instead of contributing to the process of development, these development loans retarded it by pre-empting an increasing share of their limited foreign exchange resources for debt service payments (Abbou, 1993).

The structural adjustment advocated by the World Bank, requiring many African countries simultaneously to increase the production of supply of traditional exports is responsible, in part, for worsening terms of trade in the 1980s, and will lead to a continued deterioration if the same policies are followed in the 1990s. This conclusion applies to major minerals - copper, aluminium and petroleum - as well as crops (See Stewart et al., 1992). For example, coffee and cocoa, accounting for nearly half of SSA earnings from agricultural primary products, Africa's share of world exports exceeds the price elasticity of demand. Thus 'an increase in the volume of SSA exports would definitely result in a fall in earnings'. A similar condition almost obtains in other commodities, including sugar; groundnuts and sisal, together accounting for over 60 percent of the SSA agricultural exports (see Godfrey, 1985: 32).

Import liberalisation is an important element of most structural adjustment packages. Although the devaluation of the exchange rate offsets some of the effects of the adoption of undifferentiated import liberalisation, this reform tends to have a sharply negative effect on industrial activity. It is true that previously highly protected industry cannot compete with international competitors, particularly when at the same time they are denied of money to restructure and invest in better technologies to meet competition. In fact, the deindustrialisation observed in many countries in the 1980s can be explained by the shortage of foreign currency. Assuming the financial crisis was not there milder, selective and temporary protection with greater use of tariffs rather than quotas could be effectively used, i.e., phased out over a ten-year period as efficiency increases (Stewart, Lall, and Wangwe, 1992). Regional trade to increase the size of the market with protection could be used in the context of export-oriented policies. But protection need be complemented by selective interventions in factor markets to ensure that the skills, knowledge, infrastructure and institutions needed for competitiveness are forthcoming (ibid.).

Furthermore, the absence of efficient large and medium sized indigenous private sector and the lack of interest shown by foreign investors to invest significantly in Africa makes the privatisation of public enterprises as neither desirable nor politically or economically feasible (Adam and Cavendish, 1991). The recent reforms in China could be a valuable lesson to SSA countries. China set up holding companies to reduce political interference. IT raised market pressures through increasing domestic and external competition. It reduced subsidisation of public enterprises and allowed joint ventures between parastatals and foreign companies. Therefore, what is needed is to increase the efficiency of parastatals through increasing managerial incentives and autonomy (ibid.).

Jamal and Weeks (1993) show that there was a general decline in export performance during the 70s and 80s in SSA countries. Of the 15 countries for which comparable data were available, real export growth was negative for only two during 1965-73, whereas it was negative for as many as 11 during 1973-84 and remained so for nine years during 1980-90. Further, while SSA countries had a considerable better export performance than all low income countries in the earlier period, they fared considerably worse subsequently. They reject the conventional explanation that blame the poor policies of the SSA countries (overvalued exchange rates, monopolistic marketing boards which set up crop prices, higher levels of taxation, subsidies, and higher and less uniform protection for industry and more use of direct controls). There is no documented profound policy shift sweeping the SSA region during the 1970s. But the fall in terms of trade of SSA, which was considerably higher than for developing countries taken together and in particular for low-income Asian countries, is one of the major contributing factors that led them into a deep economic recession and stagnation.

Wage earners have been represented as a privileged and perhaps parasitic class in SSA Observers across the political spectrum endorsed it. It fitted well into the neo-classical anti-wage-labour bias, and even the 'inappropriate technology' school agreed with the neo-classicists that wrong techniques were being used and that no set of relative factor prices would put the matter right. But Jamal and Weeks (1993) argue against it and wonder why 'the Great Depression of the West brought on a thorough going reappraisal of accepted economic wisdom. On the contrary, the Great Depression of Africa has prompted in the West the rejuvenation in development economics of precisely the dogma, which the crisis of the 1930s had discredited once and for all'.

Many have also voiced strong criticism against corrupt government systems in SSA countries. They say that confidence in the public sector is ever diminishing. These are full of inefficiencies and maladministration. The once Executive Secretary of the Economic Commission for Africa, Adedeji correctly said that the poor economic management of economies in Africa has put a question mark on the ability of the public sector to play a dynamic role in the development process. They have become 'a self-perpetuating, self-centred and self-aggrandising cabal' (Ravi Gulhati, 1989, p. 57). Some leaders have gone too far to plunder the economy such as the Mobutu of Zaire and some military leaders in Nigeria becoming the real problem to industrialisation and development, in otherwise richly endowed countries. The political instability of many SSA countries can be even attributed to the kind of political leadership they have.

Now that we have given some of the major economic policy debate, let us turn specifically to S&T issues. The available limited S&T capabilities in SSA countries can be seen in the above broader context in order to have a better understanding of the complex issue at hand.

The de-industrialisation process, that started after the oil shock of 1973-4 and continued during the 1980s, has raised a number of questions particularly those of S&T development in Africa, which is the interest of this research. Even though, the Dakar Declaration of 1974 (see Appendix 4) was very explicit about what should be done to redress the African scientific and technological capacity, nothing had been done to avert the de-industrialisation in SSA of the 1980s. We do contend that SSA countries failed in the process of industrialising because their macroeconomic policies were not integrated with appropriate technology transfer choices and implementation management. At the same time the political and social environment was not conducive for development in general. Now let us focus our attention on the S&T policies and the structure of the policy-making bodies in its dynamics.

The international agencies such as the UN - through its various Departments such as UNESCO, UNECA, UNDP, and WHO - has tried to assist African countries to reverse the vicious circle through better health, education, and S&T development. The thinking of these agencies have been guided by the firm belief that Africa should have the necessary human capital to be able to take its fate in its own hand. In this line, UNESCO (1979) has proposed and tried to promote an S&T model to help the poor developing countries get out of their vicious circle. The model is also known as the 'UNESCO Model'. This model is composed of five parts:

1. Planning: setting technological goals and developing matching policies and action programmes for achieving them;
2. Co-ordination: monitoring other institutions' activities in technological fields and aligning them with existing policy;
3. Implementation: carrying out specific action programmes in selected technological areas;
4. Advice: providing information to the government and the public on technological issues; and
5. Advocacy: mobilising support and resources for the advancement of technology.

This model advises that the place of such an institution preferably be in the office of the head of state under the direction and supervision of the president of the country himself.

With the belief that S&T policy instruments are very useful to accelerate the development of science and technology, particularly for the less developed countries, the 'UNESCO model' has been pushed on to them. Let us have a closer look at it. This model is based on the notion that technology policy (or plan) is the legal and political expression of a nation's leadership desire to enhance the contribution of scientific and technological capabilities for national development. It was meant to reduce the tendency and attitudes of the productive sector to rely on foreign technology. In other words it is a deliberate choice, it is a commitment to that choice, and it is the act of co-ordinating all the activities the leaders of that given country make in order to achieve a sustainable development. Otherwise, every individual enterprise and the different government ministries, departments and institutions will pull in different directions and the economic development will be hard to achieve. UNESCO model's framework incorporates technological priorities (choices); building up of indigenous technological capabilities (strategies to be adopted); technology transfer mechanisms; infrastructures suitably equipped with skilled manpower and equipment to meet operational international standards; funding institutions and enterprises with defined roles in the development of indigenous capability; co-operative models for mutual benefit at regional and international level; definition of policy instruments from planning to evaluation of performance by various institutions, the objectives of the national development plans being the yardstick throughout; and the gradual building up of a national potential in high technologies.

Early on, we have been discussing about macroeconomic policies because they set the ground for the S&T policies. Policy-making bodies are the prerequisite for the development of appropriate S&T policies. This is an area where a lot remains to be done in the SSA countries, even though, considerable improvement have been made in this regard. One of the major constraints for such bodies is lack of resources. We do perfectly agree with Vitta (1993) when he says: 'So disproportionate are the means and the ends that the institutions lack of resources amounts to an unspoken agreement between the institutions and their sponsors not to take their mandates too seriously.'

With regard to the requirements of the UNESCO Model, Vitta (ibid.) says that even those institutions that claim to be directly under the office of the head of state never get the personal attention they expect. They are mere formalities. The power conflict between the technology policy institutions and the ministries is in the very structure of the way many African countries work. It is a recurring feature in the statutes of many African institutions for technology policy for the state to enact a statute requiring an institution to regulate activities of rival institutions hierarchically at a par with it, or even above it. This amounts to installing a bias towards failure in that institution right from the outset (ibid.).

If you look things from the professionals' point of view, you would see a different picture. It is possible to say that African professionals are not completely free to exercise their expertise. Particularly in regions where there are repressive regimes, the.se professionals refrain from giving their expert advice for fear of reprisals from those in power. To avoid this they prefer to exactly do what they are told to do rather than to risk. Anyway they know that only those people that know 'how to win friends and influence people' will end up making the decisions. Usually the professionals are not among them. If you are pushing a particular policy very hard and it is not liked by those who control power for whatever reason, you may end up labelled as 'the opposition' and soon will lose only your job, if you are lucky.

At times the institutions have the fund and the right policies but the 'implementation' is poor. The reasons for such poor performance are many. Among the major ones are: lack of strong and professionally motivated leadership, lack of skilled manpower, lack of properly designed incentive systems, brain drain, and lack of institutional accountability. These problems are all interwoven. For example, let us say that the head of the technology institution is a political appointee. His being loyal to the government has earned him the position and will help him to retain it or move into higher positions. The incentive to professionally work is not in sight. Reward and performance are not linked. He cannot be a source of inspiration to the people he leads. What he is and what he does gives a message that 'loyalty more than performance is what counts'. The professionally oriented people will not be motivated to work in such a place. They will be the first to leave the institution. This will increase the brain drain. The institution most likely will be the place for average people who are interested in keeping their jobs through loyalty to their immediate bosses. As a result the institution does not live for the objectives for which it was established but its own survival. In such institutions corruption thrives easily because accountability has been eliminated.

It has been suggested that African policy researchers and analysts should do something to change the negative situation of poor technological performance. Incremental change within the status quo or radically through new structures is the possibility (Vitta, ibid. p, 38, 38). The incremental change is possible in a stable work environment where there is continuity, which requires a higher institutional maturity than what is available in SSA, given the frequent office reshuffling and change of people because of political motives not known to the analyst. The radical change is even much tougher because it assumes a considerable power on the side of the analyst, which is never the case. Therefore, there is not much that the policy analyst can do unless a host of other variables in the political landscape change too.

Many good policies failed because they were not properly communicated. Particularly in Africa, where there are traditional institutions living side by side with the modern formal institutions, communication is of singular importance to mobilise the people toward a common development objective. The lack of integration of these two institutions has led to a lot of conflicts that have contributed to block the road to quick progress. Indigenous channels of communication can serve as powerful instruments of change such as the culturally based channels of communication over technology-based mass media in reaching out to rural population. It is possible to blend traditional and modern systems of communication, thereby converting the modern channels into two-way, interactive media, can maximise the impact of messages (Dia, 1996). Development planners and designers generally bemoan Africa's lack of capacity to exploit its resources. The experience of Eritrean Popular Liberation Front (EPLF) and Tigrean Popular Liberation Front (TPLF) largely belie this. They indicate with a clear policy, strong political will, and appropriate human resources; Africans can successfully tap their local resources (ibid. p.2a9). Unfortunately, these very two countries are engaged in a conflict of border dispute since the mid-1998. The irony is that the leadership of these two countries was considered among the 'New Hope' for Africa. This is a good clue why Africa is remaining behind by losing its energy into unnecessary internal and external conflicts. There is always possibility to resolve conflicts without resorting to force, this is what Africa should learn most and quickly to save its entire energy for the eradication of poverty and underdevelopment.

Policies to be effective should be accompanied by appropriate reward and incentive mechanisms. In other words the direct or indirect rewards and incentives should be in line and not militate against the policy. These rewards and incentives need not be confined only to the people whose behaviour is to be influenced but also to those things with which the people closely identify with (Vitta, 1993).

The conclusions we get from the above analysis is that Africa, with the help of UN agencies' consultants, have established science and technology policy making bodies and produced policies that remained mostly unimplemented. The major reason is that most of the SSA countries are politically unstable and also heavily indebted. These factors are denying Africans the basic environment and resources to build S&T to support their economic development.

7.4 Institutional capability

'Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction'(North, 1990). In the industrial context these provide finance, information, services, standards, export assistance and the like, but the required network is not thrown up automatically by the market. Thus, it is frequently needed active state support, especially in science, technology, education and infrastructure (Lall, 1992).

Creating S&T institutional capacity in SSA countries would mean a greater ability for countries to make optimal use of the existing technical capacity and resources in a sustainable fashion. The focus here is on capacity utilisation and absorptive capacity. In most African countries, the broadening of the institutional base has tended to weaken the system as a whole instead of strengthening national S&T capabilities, since new institutions have seldom been established on a planned basis with due attention to existing structures and medium- and long-term requirements. The increased number of institutions has, therefore, often led to the dispersal of scarce available resources (human, material and financial) among projects and programmes with similar objectives; as a result a widespread lack of effectiveness is to be observed (UNESCO, 1988, p175). Many researchers now and again are saying that the problem with SSA countries is the weakness in the institutional side of capacity building, particularly that of science and technology. Based on the World of Learning 1995 (Table 7 .5), the countries with relatively significant scientific and technological institutional development in SSA countries are Nigeria, Kenya, Ghana, C6te d'Ivoire, Senegal, Congo (Rep.) and Cameroon. The rest are basically at the initial stage. What is most important is not the number of institutions but the quality, which in SSA countries is basically absent.

Various forms of organisation for S&T policy structures have been tried out in Africa. Some countries have established autonomous bodies with legal status and financial independence, while others have set up ministries, which are concerned exclusively with S&T research or else have this responsibility among others. Here below, we will see the experience of those considered to be advanced by the SSA countries standard.

Kenya has established its National Council for Science and Technology (NCST) in 1977 (Parliament Act 19'/7, chapter 232) It comprised four Advisory Research Committees in Agriculture, Medical, Industrial, and Natural and Physical Sciences. When the East African Community collapsed in 1979, the Act 1977 was amended and five semiautonomous research institutes were established: Kenya Agricultural Research institute (KARD, Kenya Medical Research Institute (KEMRI), Kenya Trypanosomasis Research Institute (KETRI), Kenya Industrial Research and Development Institute (KIRDD, and Kenya Marine and Fisheries Research Institute (KEMFRD. The Council's basic responsibility is to formulate policies and plans, advise the government on priorities and co-ordinates research; while the advisory Research Committees formulate strategies for implementation of the policies and plans; and finally, the Research Institutes carry out research and technology development activities (UNESCO, 1987, p.118). NCST was first put under the authority of the Ministry of Planning and Community Affairs. Later, it was placed under the Office of the President, Cabinet Affairs (1979), under the newly created but short-lived Ministry of Regional Development, Science and Technology (1982), and finally after the reorganisation of Government ministries, under the Ministry of Education, Science and Technology (1983). The fact that NCST reports to the Ministry of Education, Science and Technology, while the Research Institutes are under their respective sector ministries, has introduced new problems of coordination of research and working relationship between them (p.121). Nonetheless, a great progress has been made to create institutional capability in S&T in Kenya and the attempt to support the socio-economic development of the country is beginning.

Ghana's National Research Council (NRC) was created in 1958 (Research Act 1958 no. 21), a year after the country took independence. Under the inspiration of President Nkrumah, national development policy and planning assumed a comprehensive and systematic character. The need to provide a scientific basis for development programmes was fully recognised. In order to do so, the country started to provide adequate resources for scientific activities and to co-ordinate such activities for national development (UNESCO, 1986, p.40). But the frequent changes of political leadership in the period since 1966 to 1982 had severely affected the support given to S&T development in the country. The NRC, as of 1962, included the President, the Minister responsible to the President for research and the Executive Secretary of NRC as 'statutory' members. There were in addition, seven nominated members (the Minister of Agriculture, the Minister of Education and Social Welfare, the Vice-Chancellor of university of Ghana, the Vice-Chancellor of the Kwame Nkrumah University of Science and Technology, the Secretary of the Cabinet, the Secretary to the National Council for Higher Education and the Executive Secretary of the State Control Commission). In 1963 NRC was merged with the Ghana Academy of Learning ending up to become the Research Division of the Ghana Academy of Sciences. Finally in 1966, the Ghana academy of Sciences was reconstituted into the present Council for Scientific and Industrial Research (CSIR) and the Ghana Academy of Arts and Sciences (ibid. p. 42). Originally, the CSIR reported to the Ministry of Economic Planning. But now it reports to the new Ministry of Industries, Science and Technology, which has the overall responsibility for the formulation and implementation of the country's industrial policy, for the development of science and technology policy and for the application of science and technology to industry and agriculture. CSIR is the principal organ through which the Ministry attempts to execute the S&T development and co-ordinating functions. The Ghana Standards Board also comes under the Ministry of Industries, Science and Technology (ibid. p. 42).

In Nigeria, the origin of science and technology policy-making date back to 1966 when it established by a decree no. 83, 1966 the Nigerian Council for Scientific and Industrial Research (NCSIR), which never came into existence. At that time, the Government asked UNESCO to help it in the task of building the S&T infrastructure. UNESCO mission undertook a .study for four years, which involved extensive consultations with relevant ministries such as Agriculture, Heath, Industry, Works and Housing, and Mines and power as well as with regional governments, universities, and research institutes. Based on the report of the mission, the government of Nigeria promulgated a decree no. 6, 1970 which replaced the previous decree (no. 83, 1966) and established the Nigerian Council for Science and Technology (NCST). This had four specialised research councils: the Agricultural Research Council of Nigeria (AREN), the Industrial Research council of Nigeria (IRCN), the Medical Research Council of Nigeria (MRCN), and the National Sciences Research Council of Nigeria (NSRCN). These research councils were established between 1971 and 1973. But NCST was replaced for being ineffective in 1977 (ibid. p. 79). Later on, the National Science and Technology Development Agency (NSTDA) was established by decree no.5, January 1977. NSTDA was given executive powers unlike its predecessor and its Chairman was made a commissioner who sat on the Federal Executive Council. The Council of NSTDA was composed of fifteen distinguished scientists. Soon after in 1979, NSTDA was transformed into the Federal Ministry of Science and Technology by an act of the Parliament, Science and Technology Act, January 1980. This body controls and manages all the 23 inherited research institutes, research programmes and activities in the country.

Cote d'Ivoire set up a Ministry for Scientific Research in 1971, Presidential Decree no. 7l-480. The Ministry is responsible for promoting, directing, co-ordinating and planning scientific research in the light of the development of science and its application to the economic, technical and social development of the country. This Ministry has a Cabinet and four Central Directorates. To the Cabinet are attached two autonomous departments and five technical advisors. Its responsibility is to make research policies, plan research activities, to co-ordinate, evaluate and identify structures and research projects and programs, and coordinate international scientific co-operations. The four Central Directorates are the Directorate for Research and Programmes, the Directorate of Administrative and Financial Affairs, the Directorate for Training, and the Directorate for Information and Publications. Besides, there is the Council for Scientific research, a consultative body, attached to the Ministry for Scientific Research to advise on directions of scientific policies. This is composed of ten ministers and sixteen scientists and it works through ad-hoc committees (ibid. p55). Cote d'Ivoire shows an impressive number of research organisations and institutions. In 1986, there were 57 of them of which 30 were universities research organisations, 6 were foreign, and the remaining public institutions and state enterprises (ibid.).

Senegal established the Counsel interministeriel de la recherche scientifique et technofogique (Interministerial Council for Scientific and Technological Research) in 1966, decree no. 66813 of October 1966. At the same time a Bureau des affaires scientifiques et technofogiques (Office for Scientific and Technological Affairs) was established and placed under the authority of the Secretary-General of the

Office of the President of the Republic. These structures operated with the assistance of an expert from UNESCO during the first decade (1960-70) (ibid. p87). In 1971the Inter-ministerial Council was attached to the office of the Prime Minister. Since then, it has been presided over by the Prime Minister. The office

of Science and Technology affairs became the Direction des affaires scientifiques (Directorate for Science Affairs) and came under the authority of the Secretary of State at the Office of the Prime Minister responsible for the Plan. This in turn became the Ministry of Planning and Co-operation in April 1973. The General Delegation for Scientific and technological Research was established in 1973 (Decree no.73-1100) attached to the Prime Minister Office and all the research centres and stations under ministries (except those attached to universities) came under its control. Later in 1979, this became a Secretariat of State responsible for the making of science policy and management in the country known as SERST (ibid. p.88).

Some writers have gone to the extent of saying that SSA has had a good supply of well educated personnel and reasonable access to new technology, systems, and methods, as well as a reasonable share of good policies. But the region has been unable to use these resources effectively because it has generally lacked an institutional base with the required legitimacy, accountability, stability, enforceability, and incentives. As a result, economic and political achievements are generally not fully institutionalised (with the needed enforcement and incentive mechanisms) or internalised by the broad civil society to make them sustainable. They are therefore prone to reversal with changes of regime and leadership (Dia, p.28). It is also true that there is a big problem of brain drain in SSA. These countries are losing the best people to the advanced countries where they can better remuneration and better working environment and facilities. But it is hardly possible to say there is a good supply of highly skilled manpower.

The number of institutions of higher learning and research has increased in SSA countries since independence. But still their quality (even their number) is very low by world standards (Table 7.5). Even the maintenance of this limited number of institutions is becoming increasingly difficult to many SSA countries. At times it is very difficult to get the required political, social and economic support to strengthen these institutions. In fact, SSA countries research institutions depend heavily on external support. Sustaining these institutions with local means only is extremely difficult and the very long-term sustainability is continuously questioned. To give an example, Kenyan higher learning institutions, which are among the best in SSA, are experiencing resource starvation and their formative years are considered by far better in terms of financial resources than the present times (Wandiga, 1996). This is because international donor support was high at the beginning and their pullout has been followed by near collapse of the system. This is evidence that sustainability was not part of the original plan. It was assumed that countries would immediately assume responsibility for the continuity of these institutions. A similar experience is being reported in Tanzania. Research in the Ministry of Agriculture is characterised as too little trying to cover too much in an extended system of research facilities at some 55 institutes, stations and substations. Many of these were developed as a part of donor assisted development projects and research stopped when external assistance stopped at the end of the project (Widstrand, 1992. p53). A study of "The flow of Information: Social and Economic Science in Sub-Saharan Africa" by Dr. E.K. Hicks et al. (1997) show that still the major problems of African researchers is lack of funds, lack of scientific literature, inadequate income, and inadequate administrative, professional and organisational resources.

Science and technology institutions in SSA countries are the exact replica of the institutions in the advanced countries. In fact, most of them have their origins linked to the colonial times or established and funded by institutions in advanced countries (at least at the beginning). They require considerable resources, which the meagre resources of SSA countries find it unsustainable. The consequence is that the

Table 7.5: Higher learning and research institutions in SSA countries.

Countries	Learned society, research institutions and academies	University	Polytechnics and colleges
Low-income countries			
Angola	7	3	-
Benin	6	1	-
Burkina Faso	10	1	2
Burundi	5	1	5
Cameroun	23	6	3
Central Africa	10	1	3
Chad	5	1	2
Congo, D R	-	-	-
Congo, Rep.	13	1	4
Cote'd'Ivoire	22	1	8
Eritrea	-	1	-
Ethiopia	15	2	3
Gambia	3	-	1
Ghana	35	3	10
Guinea-Bissau	5	2	5
Kenya	41	4	12
Lesotho	4	1	1
Liberia	8	1	3
Madagascar	16	3	3
Malawi	22	1	-
Mali	12	-	7
Mauritania	3	1	3
Mozambique	7	1	-
Niger	12	2	1
Nigeria	57	23	26
Rwanda	-	-	-
Sao Tome and Principe	-	-	-
Senegal	27	3	6
Sierra Leone	9	1	4
Somalia	10	1	6
Sudan	13	8	4
Tanzania	18	3	12
Togo	12	1	4
Uganda	15	3	1
Zambia	20	2	5
Zimbabwe	54	2	10
Lower-middle-income			
Cape Verde	-	-	-
Djibouti	-	-	-
Equatorial Guinea	-	-	-
Namibia	7	1	1
Swaziland	7	1	3
Upper-middle-income			
Botswana	3	3	4
Gabon	6	2	2
Mauritius	7	1	3
Mayotte	-	-	-
Seychelles	1	-	2
South Africa	102	19	13

best brains leave them for better salaries abroad and the quality of these institutions has been observed to deteriorate over time. But we cannot agree more with some of the authors that have suggested that SSA countries have to think themselves out of their current predicament (Court, 1991), which should have been present in the making of these institutions in the first place. Research capacity is essential for the development of these societies (Nelson, 1995; Thulstrup, 1995) and thus research funding should be part of their culture. Basic but adequate scientific infrastructure need be developed to support the research activities of African researchers including an adequate remuneration. The idea that SSA countries cannot engage themselves in scientific activities is dangerous. Thinking and searching is natural and it is part and parcel of any society. What is required is new and innovative way of organising research resources to minimise costs and maximise benefits. A new model that suits the developing countries need be found.

Wandiga (1996) based on the experience of Kenya said that universities' research activities are insignificant and tend towards the basic research and the few applied researches carried lacks clear mission. If this is said of a country, which together with Nigeria is considered the research power of SSA countries, what can we expect from the rest? In a similar vein, E.Bekele (1996) tells us that in Ethiopia research is biased towards the biological, agricultural and medical sciences; and that they do not fully cater for the R&D needs of the various ministries, research institutes and industries. He notes also that material incentives for researchers, in addition to academic promotion, would be needed to encourage staff to give up part time work and concentrate on research as a strong R&D tradition cannot be expected to develop in a community of disgruntled academics. Basically the same is true of all the other SSA countries and concrete measures need be taken to correct the situation.

It is important that we look also on how the S&T institutions in SSA countries are making and diffusing S&T results. The universities, the industrial research and development institutes, and the enterprises are the main players in the development and promotion of appropriate industrial technology and human resources. Below are presented ECA findings on the impediments to such institutional capacity building and the lack of competitive industries in SSA.

The impediments observed in the universities are the following:

- Divergence of opinion amongst university dons on the "publish or perish syndrome"
- The gap between the national development plans and their translation into national technological plans from which researchers can select R&D programmes
- The ineffective collaboration between institutions of higher learning and other relevant authorities to train the required manpower with specific status and skills needed to implement technology plans within a given time
- The lack of adequate institutes of technology having the competencies to appreciate the lengthy process and complexity of skills for the development of indigenised industrial technology

From the industrial research and development institutes' point of view the following impediments have been identified:

- Total absence of technology registry to expose young scientists and engineers to a wide variety of technologies and patents
- Lack of conscientious effort to appreciate the inter-dependence that should exist between industry, science and technology institutions and policy makers, resulting in total or partial absence of u organised and integrated approach in the selection and execution of S&T programmes

- The Prevalence of the dominant school of thought that university education in general qualifies the recipient to be more capable of finding solutions to technological and business problems, rather than the operator of the business in question
- Lack of conscientious effort and support to study, upgrade and adapt indigenous techniques to a level of mass production in industry.
- Inadequate funding of R&D.
- Lack of satisfactory working conditions and adequate remuneration und incentives resulting in high turnover of manpower
- Lack of employment opportunities in the industrial sector of the nation leading to brain drain According to UNESCO, the number of scientists and engineers involved in R&D in Africa is only 0.4% of those in developed countries.
- Shortage of infr6ttucture Some countries do not have even a bureau of standards, others lack industrial R&D institutes, technology registry, industrial consulting services, small industry promotion agency, engineering design and prototype manufacture, and most important of all a powerful and competent policy implementing agency.
- Lack of competent staff in the policy making body, where the competence required involves industrial technology management, consulting experience or exposure to technology registry mechanism, information expertise, in-depth knowledge of patenting system, etc. Having scientists without any of these exposures and experience in key positions cripples the institution and whatever their levels, they will proceed cautiously.

Poor status is given to industrial scientists in decision making and it is compounded by lack of financial compensation, as opposed to social scientists, lawyers, and business administrators, who are given the opportunity to fully participate in the important decision making processes of the country. On the other hand, the constraints hindering the enterprises' contribution to the development of local capacity in R&D are considered to be:

- The dominant thinking prevalent in the local enterprises that the best markets from which to purchase (acquire) technologies or research services are all outside the continent's borders. This attitude reflects how little of the R&D capability to develop technology, is known by potential user enterprise, and by inference, the low level of confidence by the enterprises in themselves regarding that capability It is also an indication that enterprise have no share allocated to them by government to contribute to any national technological endeavour Most serious of all, this situation is a reflection of inadequate level of communication between the planning mechanism for S&T development and the user enterprises
- Lack of package of incentives to attract the production sector into the training of professionals and ultimate involvement of risky ventures such as commercialising indigenous innovations and inventions Some countries have an investment promotion organ, which spells out certain concessions, but here again, the level of involvement, which was deployed in arriving at the above package, will determine the degree to which the enterprises will be tempted to "bite the bait".
- Lack of close involvement of industry in government plans The hallmark of success in using enterprises to assist in the implementation of development plans depends much on the level of interest existing between the government and ii5 industry support services on the one hand, and the enterprises on the other This bond is one of mutual understanding of what the government is Planning to achieve, how and when, plus the expected contribution from the industry and under what conditions Such collaboration reveals the determination of each partner while simultaneously enhancing the industry appreciation of local R&D capabilities

- In some countries, there is lack of appreciation of the relationship between the level of development of manufacturing activity and progressive development of a nation Efforts are therefore not intensified right from the educational programmes to breed scientist and engineers who can assist in the development of the industrial sector The €nterDris6 under such situation therefore do not have the appropriate manpower to make them effective.

More can be said of gaps in the innovation system in Africa. The major ones are the scarcity of information about easily assimilable technology and the lack of support made available for technical entrepreneurs. Information lack is leading to re-inventing the wheel with the consequent duplication of efforts and wastage of resources. Technical entrepreneurs don't get the required support such as raising capital, conducting needs analysis, designing appealing products, calculating risk, and establishing distribution channels (See Tiffin, Adjebeng-Asem, and Afofabi, 1987; Davis, Tiffin, and Osotimehin, 1994).

Ideally, even a small, relatively poof country should possess the requisite institutional linkages, actors and resources to ensure the selective generation and adaptation of at least some kind of technology and their diffusion throughout the appropriate sector. However, when scientific, technological or managerial skills are not locally available, institutional gaps prevent effective deployment of capacity. Vertical complementary assets analogous to those available in developed countries to facilitate the movement of technology and skills through the economy are a necessity in Africa. Many Africans in the public sector are called upon to work on projects involving technology transfer or industrial development. But many are unfamiliar with the dynamics of technological change or with the institutional structure of innovation systems (Reddy, Aram, and Lynn, 1991; Davis, Tiffin, and Osotimehin, 1994). Usually there is bias towards science-producing institutions such as universities, public laboratories or technical schools. But that constitutes only part of the entire universe of science and technology institutions. SSA countries lack familiarity with such innovation support mechanisms as credit schemes, management services, marketing advice, technical outreach services, co-operative arrangements, business incubators, tax incentives, and many other devices for the promotion of innovation which dot the technology policy landscape in industrial countries.

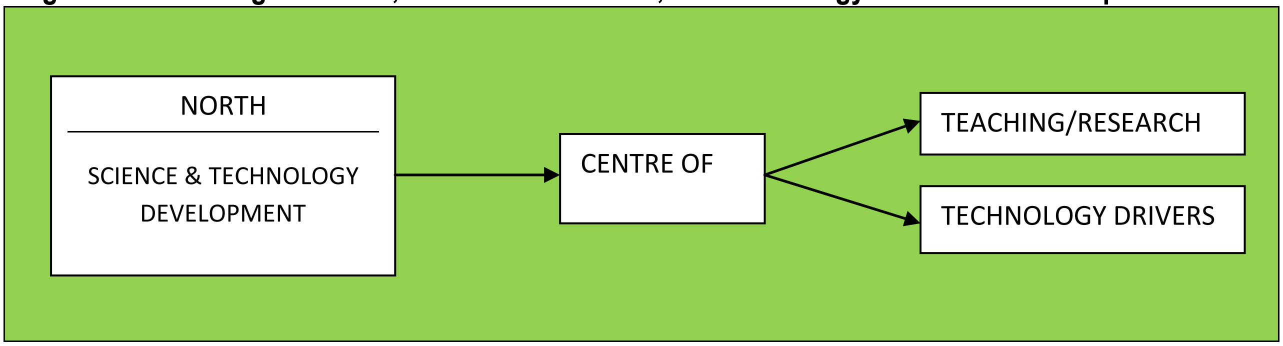
To help overcome the difficulties of SSA countries, some authors have proposed a Management of Science, Technology and Innovation (MSTI) research and service initiative in Africa (Davis, Tiffin, and Osotimehin, ibid.). They propo.sed a regional MSTI with the following characteristics:

- It should aim to create a regional network with national or sub-national centres.
- Al least one of network's nods should include a university-based MSTI teaching and research unit of international stature.
- International and national services should jointly fund the network and its components.
- The network should be service - and action-oriented It should mobilise the full range of services necessary to grow competitive businesses These services can be roughly classified as follows:

1. an investment fund that can make smart patent investments;
2. institutions, programs, information, and events for training in all aspects of business and management:
3. infrastructure for all aspects of technical, management and marketing services;
4. social networks, apprenticeship and mentoring opportunities;
5. Policy, management and strategic planning leadership at various levels: local, sector, metropolitan, national, etc.

The service activities should be organised on a sector basis and should be delivered by non-governmental organisations, with some costs recovered The argument is that the teaching and research units, small number of centre of excellence (to keep up with scientific and technological development), and a local group of 'technology drivers' are the three inter-related components of network necessary in building science and technology base for competitive industrial development in Africa (Figure 7.1).

Figure 7.I: Teaching/Research, centre of excellence, and technology-drivers relationship



In this context 'technology drivers' refer to organisations which provide technical, managerial, administrative and financial services to firms, that could be co-operative industrial technology centres supported by industry to provide technical assistance, training and networking facilities. Or university-industry (Laboratory-industry) active interfaces to promote and commercialise the knowledge assets of universities or public labs by providing services such as: policy research, management and financial advice, market research, computer and software services, technology transfer, seminars, training, translation, testing, and other consulting services. The precise configuration of technology drivers depends on national economic priorities and the level of organisation of local economic interests.

Moreover, international, regional and sub-regional networking is of great help. Particularly international development agencies have in different ways contributed towards the development of S&T in SSA countries, The prominent one has been UNESCO but there are many other such as UNECA, UNDP, UNIDO, WHO, FAO, and other development agencies such as SAREC, DAAD, CIDA, IDRC, ICTP, AREC, NORAD, NUFFIC, USAID, FINIDA, DANIDA, GTZ, ODA, SIDA, AERC, CODESRIA, OSSREA and the British Council. On a bilateral basis many of the developed countries governments have helped in the development effort of the SSA countries through the above mentioned agencies or directly, which usually categorised as foreign aid.

There is lot of debate ongoing with regard to foreign aid for development in the developing countries. Commenting on the magnitude of donor assistance to Tanzania and its side effect, Carl Widstrand (1992) has noted that more than USD 10 billion donor money have sunk since 1970. The amount has overtaken exports in value terms in the form of budgetary import support and project and technical assistance financing. The rate of dependency on foreign aid is so bad that the yearly 'Paris Club' consultations can dictate anything to the country's leadership. Similarly with regard to donor co-ordination, Widstrand have said that the capacity for co-ordination is very low among all partners. There were enormous gaps in knowledge about projects between donors, especially in research projects, which usually do not top the priority of the big donors. There were cases of financing of identical projects and even a deliberate exploitation of donor co-ordination inefficiency. Nowadays because of online information through the Internet, it is likely that there is greater donor co-ordination than in the past.

Networks at international, regional and sub-regional, and national levels are very important for the diffusion of science and technology information. It is also the basis of greater coordination and co-operation. In SSA countries this possibility has been hampered by the low level of availability of transport and communication services. Ms. Lalla Ben Barka, Assistant Secretary General of UNECA addressing the Africa's Transport and Communications Ministers Meeting (May 25-26, 1999), said that the lack of appropriate policies and regulations have hampered the realisation of the full potential and possibilities of the sector. With just 1.3 km per 1000 sq. km of tarred road and 2.8 km per 1000 sq. km of railroad, Africa is far behind the rest of the world. That is why more need to be done to create regional and sub-regional science and technology information databases, research and training networks, and a network for African scientists to enable them share experience and information. Some networks have emerged. For example, African Network of Scientific and Technological Institutions (ANSTI), African Research for Solar Energy (CRAES), African Regional Centre for Engineering Design and Manufacturing (AREEDEM), and African Regional Centre for Technology (ARET). Similarly, Sub-regional projects and programmes had been set up, sometimes with the assistance of international organisations, to solve certain common problems, in particular in the agricultural, heath and transport sectors.

The crucial role played by the triad of good policy, good institutions, and good leadership in the strong performance of East Asian countries has been repeatedly confirmed. Good leadership is generally the starting point (as in East Asia, for example), with good institutions providing the necessary link between leadership and policies (World Bank, 1993). On the contrary, poor performance of SSA countries is largely due to patrimonial distortions in the management of the state (Dia, 1993). This state of things should be reversed, if any worthwhile development is to take place in Africa.

7.5 Human capital formation

It is well known that 'skilled manpower' is central to technological capability, thus, to effective industrialisation. African economies are potentially rich in human resources, yet people are relatively neglected, badly educated and in poor heath with their capacities frequently underused. The consequence is low labour productivity and lack of competitiveness compared with countries where human resources are more fully developed and better used. This is so despite the fact that low wages should make African economies very competitive (Helleiner, 1992).

Where human capabilities have developed, unattractive conditions of work have frequently led to massive blain drain. It is estimated, for example, that there are more African graduates working outside Africa than those employed in African countries. Ghana is estimated to have lost 50 percent of its doctors between 1981 and 1984 (Stewart, tall, and Wangwe, 1992, p.34). Only the Council for Science and Industrial Research of Ghana between 1980-85 and 1986-91 lost 68.3 and 37.8 percent respectively of its trained research staff to outside organisations locally and abroad. But improved facilities and incentives helped to reduce that figure to l0 percent in 1995 (Assoku, 1996). In general in SSA countries, the scientific personnel is mainly found around universities and research institutions. The official wages of these scientific personnel is ever decreasing because of inflation and static wage structures that don't adjust to the living cost of the country. To take an example in Tanzania, university salaries of 1992 were around USD60 per month, which carries a family for 20 percent of the month and the researcher can therefore devote 20 percent of his time to university teaching and research for survival reasons. The result of which is research productivity and teaching suffers and good researchers seek positions outside the country (Widstrand, ibid. p. 104).

It is to be remembered that the Dakar Declaration had recommended 2000 scientists and engineers per million inhabitants for countries with GNP $200 and above; 1400 scientists and engineers per million inhabitants for countries with GNP between $100-$200; and 1000 scientists and engineers per million inhabitants for countries with GNP below $100. These targets had to be achieved by 1980. But none of the SSA countries have been able to achieve it by the agreed time. But now, all the countries on the African continent have institutes of higher education, except for Cape Verde, Comoros, Djibouti, Equatorial Guinea, Gambia, and Guinea-Bissau. In the 43 countries that offer higher education, the total number of students rose from 142,000 in 1960 to 1,169,000 in 1980 (UNESCO 1986). Table 7.6 gives trends in numbers of students in higher education, per 100,000 inhabitants, and percentage of female students of the SSA countries. All the countries surveyed showed a steady increase in the number of students over the years, except Uganda that showed a decrease in 1980, may be because of the protracted civil war. Percentages of female enrolment are relatively low. Only Botswana, Madagascar, and Swaziland show enrolment higher than 25 percent.

Table 7.6: Students in higher education per 100,000 inhabitants.

Country	1975 total	%F	1980 total	% F	1983 total	% F
Angola (1)	-	-	28	16	33	-
Benin (1)	70	15	-	18	172	16
Botswana	62	32	102	40	142	44
Burkina Faso	19	20	27	22	51	22
Burundi	27	11	46	25	48	-
Cameroon	113	15	134	-	-	-
Congo	241	10	475	15	-	-
Cote d'Ivoire	106	17	239	19	-	22
Ethiopia	-	-	45	32	46	11
Gabon (1)	101	20	-	-	270	26
Ghana (2)	93	16	138	21	-	-
Guinea (1	289	18	368	19	261	22
Equatorial Guinea (2)	-	-	317	10	-	-
Kenya	66	-	77	25	75	29
Lesotho	-	-	-	-	188	59
Liberia	152	22	210	28	-	-
Madagascar (1)	110	52	260	-	354	-
Malawi (1)	30	16	38	28	38	-
Mali (1)	47	10	23	11	78	12
Mauritania	126	14	109	31	69	30
Mozambique (1)	-	-	8	21	9	-
Niger	12	10	27	20	42	22
Nigeria	66	16	186	-	-	-
Uganda (1)	49	18	44	23	52	27
Central Africa Rep.	33	-	75	8	99	10
Rwanda (1)	25	-	24	10	24	15
Senegal	172	18	238	19	191	21
Sierra Leone	54	16	55	-	-	-
Somalia	65	11	-	-	-	-
Sudan	133	16	153	27	-	-
Swaziland (1)	210	39	336	40	287	-
Tanzania	19	14	-	17	31	-
Chad	14	5	-	-	-	-
Togo	104	14	187	15	145	-
Zaire (1)	101	-	100	-	105	-
Zambia (1, 2)	174	14	129	-	134	22
Zimbabwe	136	-	113	-	219	22

Source: *Report of the Ministerial Conference on CASTAFRICA ll, 1987, p. 17 [- = Not available; %,F = percentage female and (l) = I982 data instead of 1983; 1981 data instead of 1980]*

In the second half of 1980s, Africa had 0..36% of the world's scientific potential (close to 20,000 research engineers and scientists). It accounted for 0.4% of the world's research and development (R&D) expenditure. It produced 0.3% of mainstream science, i.e. published, listed, cited, and commonly used science (see UNESCO, 1985; Davis, 1983; and Braun ET al., 1988). Nigeria and Kenya had one third of the total scientific potential and one half of the scientific output in the SSA (Gaillard and Waast, 1993).

It is an established fact that at the heart of SSA countries' poor industrial performance lies the lack of skilled manpower. Then, it is appropriate to ask what is the critical mass of skill that Africa needs to take off? Enos (1991) in his book 'The Creation of Technological Capability in Developing Countries' approaches the whole issue of technological capacity development by looking into (l) nurturing of skills, (2) creating of organisations and (3) instilling of purpose. while doing so, he looks into the primary, secondary, and tertiary sectors of the economy separately, but he defines these sectors slightly differently from what they are customarily defined. In the primary sector are included agriculture, livestock raising, fishing and forestry. In the secondary sector are included those activities involving the processing and distribution of goods, including mining, manufacturing, transport and communication as well as all the technical institutions serving them including research and development organisations, design and construction firms, engineering and management consulting, and the armed forces. In the tertiary sector are grouped banking and finance, medical care, wholesale and retail trade, the administrative branches of government, education, and private services as well as those technical organisations that provide them with the knowledge they need.

Based on the above structure, Enos tries to estimate the number of individuals to be trained for a hypothetical illustrative developing economy of a popular on of 20.4 million people with a GNP per capita of $420 and percentage of GNP arising in manufacturing considered to be 14. Enos had determined the best policy for a developing country lacking technological capability and wishing to substantially increase its rate of economic growth. This policy suggests, first, to use the scarce resources of that developing country to create the ability to master technology, and after this ability has been adequately created, the country's scarce resources should be allocated to installing and operating the techniques. The conclusion seems to be nothing special and intuitively logical but Enos had to derive it from a quantitative growth model (p. 129).

Table 7.7. Estimates of cumulative numbers of technically trained persons needed to absorb the modern techniques to be adopted during the production programme (years Y + 8 to Y +2O)

Skill Level	Primary sector	Secondary sector	Tertiary sector	Total economy
Basic	-	200,151	183,635	383,786
Medium				
Agricultural	154,200	-	-	154,200
Industrial	161,000	50,131	10,506	221,637
Commercial	24,560	25,241	32,892	82,693
Nursing	-	-	3,799	3,799
Teaching	-	-	37,410	37,410
Total	339,760	75,372	84,607	499,739
High				
Agr. scientists	41,300	-	-	41,200
Engineers	800	5,589	7,574	13,963
Doctors/dentists	-	-	2,389	2,389
Total	42,000	5,589	9,963	57,552
All levels	381,760	281,112	278,205	941,077

Source: I L Enos (1991),The creation of technological capability in developing countries, p 135

Enos has tried to make a 'manpower planning', a twenty-year plan, for that illustrative developing economy we have mentioned earlier. He says that 'the county's acquisition of sufficient technological capability is assumed to take the first seven years of the country's Twenty Year Plan, this interval being consistent with optimal policies derived from the two growth models he did develop. Thus, year 1 to 7 of the plan are devoted to building technical competence, and year 8 to 20 to installing and operating (with an adequate number of technically trained persons) modern techniques. Based on data provided by Roerner and Stern (1981) and making his own assumptions, Enos arrives to the estimates given Table 7.7.

This Twenty Year Plan is designed to double the national income and output of the developing country but the necessary increases, according the calculation of Enos, in the number of trained persons are of highest orders of magnitude. The next table gives a better view of it (see table 7.8).

Table 7.8: Estimates of the numbers of technically trained persons needed to sustain production

Skill Level	No. Of technically trained persons needed		Gross average annual rates of growth (%)	
	Beginning of plan (year T)	End of plan (T+20)	Average over the plan (T to T+20)	Over the production phase (T+8 to T+20)
Basic	1,605,000	1,988,786	6.1	6.7
Medium				
Agricultural	3,000	157,200	27	39
Industrial	8,000	229,637	23	33
Commercial	5,000	87,693	21	28
Nursing	1,500	5,299	14	19
Sub-total	(17,500)	(479,829)	(23)	(32)
Teaching	100,000	137,410	6.6	7.5
Total	117,500	617,239	14	19
High				
Agr. scientists	1,000	42,200	26	36
Engineers	2,900	16,863	14	20
Doctors/dentists	1,000	3,389	11	16
Total	4,900	62,452	19	27
All levels	1,727,400	2,668,477	7.3	8.5

Source: Enos, ibid. P. 136.

If we assume that what Enos has derived is fair representation of the actual needs of developing countries, then, the implication that follows is that a lot of training is required which, evidently, seems beyond the capability of the developing countries. This elasticity of demand for technically trained persons are far beyond what one might expect, and yet if we look at the figures in more detail we should not be surprised. There is plenty of evidence from developing countries that they need far more technically trained persons. All this evidence indicates that there are substantial needs to fill. These needs are relatively most acute where medium-level skills are concerned, as reflected in the differences between the current stocks of persons with medium level skills in agriculture, industry and commerce and the stocks needed to exploit modern techniques planned for adoption. In the illustrative economy, current stocks are, on average, only one twenty-fifth of the stock needed by the end of the twenty-year Plan (p. t37).

The portion of the relevant age groups with technical training should be, therefore, one in ten. This is assuming that both girls and boys were to have access to the various vocational courses, and allowing for wastage rate of 5 percent per year for those who are being trained, or have received their training, one comes up with an estimate of one in ten. This ratio is exactly equal to the portion of secondary school students receiving vocational education in the republic of Korea (Amsden, 1989, p.224).

Therefore, everything seems to point out that African countries are required to make heavy expenditures on human resources development if any chance of taking off and catching up the advanced countries in the coming decades is going to be possible. Where from will these funds come, from aid and loans? Is it possible with the existing heavy burden of debt? It is obvious there is no simple solution. A lot of creative thinking is required. Some of the creative ideas should deal for example on how to stop all conflicts in Africa and reduce defence budgets to minimum and use the money for education and health and development.

Recently, the World Bank has come with a new idea of how to help meet the Sub-Saharan African countries' demand for highly skilled manpower. It established, in 1997, the African Virtual University (AVU). The objective of the AVU is to build world-class degree programmes that support economic development of Sub-Saharan African countries by educating and training world-class scientists, technicians, engineers, business health care providers, and other professionals. It did start with 12 universities in the English speaking countries of Ethiopia, Kenya, Uganda, Zimbabwe, Ghana, and Namibia; followed by 7 French speaking countries and 3 Portuguese speaking countries. The plan is to have 25 sites operational in 1998.

AVU is a first-of-its-kind interactive-instructional telecommunication network. The World Bank finances the supply and installation of satellite receiver terminals at the universities. Programme course package consists of videotaped and live lectures supplemented by class notes, textbook and homework. Internet based courses as a free standing as well as enhancements to the video-based lectures were also in plan. A digital library programme to make scientific information available to African students and faculty was being developed (http://www.avu.org/english/aboutisum.htm).

Similarly, UNESCO is promoting the Satellite University of Science and Technology (SUST). It was initiated in collaboration with the National Technology University of Colorado (USA) to produce post-graduate, scientific and lifelong learning programmes for distribution to participating schools, universities, homes and work places. With the Cairo University of Egypt serving as the Arab ho.st of SUST, Nigeria will serve as the host for the rest of Africa' But what is the chance of the sustainability of such .satellite based higher education systems, assuming it works well? Is it not going to create another dependency No one can tell at this stage?

It is a very welcome help from the international community to reverse the bad trend of illiteracy, lack of education, S&T backwardness in the SSA, but African governments and people should take their destiny into their hand. No excuse is acceptable for not doing enough for education and technical training. The best possible of wealth distribution is education. What could be more desirable than educating people to help themselves?

7.6 The Melting Pot: technology management and economic development

When we were discussing the 'technology management of the NIEs', we had followed a particular structure: organising, networking, learning and competitiveness, Given that The SSA manufacturing industry in the world market is non-existent, that structure is less important. Therefore, we focus more on industrialisation policies' implementation, World Bank restructuring impact, and S&T policies and implementation.

SSA countries' national development plans took little account of S&T. These plans seldom contain a clear translation of socio-economic objectives into scientific and technological objectives together with a description of the research programmes to attain tho.se objectives and a statement of the necessary financial resources (UNESCO, 1988, p187). The reasons given by the same report for the poor integration of S&T into national development plans are basically three. The first is lack of complete and reliable record of scientific and technological potential (resources available for the study of all problems involved in application of S&T to development). The second is lack of skill of policy-makers in planning and programming research activities and the process of integrating them into national development plans. And, the third is the fact that the main research bodies in some countries are the local outposts of foreign institutions, which have no link with the socio-economic objectives of the country (ibid. 187-8).

Let us now for a while focus on industrial technology in SSA countries. These are basically intertwined with the industrial policies and economic policies in general. Inadequate industrialisation policies left African countries dotted with 'white-elephant' types of manufacturing plants that were not sustainable because, the required institutional support, for adequate learning to transfer the technologies to make it sustainable, was not there. Besides, the rapid industrialisation attempt made during the 60s and 70s were made by plunging into debt the continent more than it can bear leading to a terrible situation of vicious circle from which many SSA countries have not been able to get out. The external shock was also very great for the African industry to withstand it.

The structural adjustment policies were basically the make of IMF and World Bank, presumably to help the continent to get out of the mess. But it has also exacerbated the situation. Two decades later, the situation in S&T in SSA seems worse than ever. Positive human resource development has been offset by brain drain problems. The policies of specialisation on primary products such as cocoa, tea, coffee, minerals and oil did not perform well for the decreasing prices of such commodities in the global markets. The global market is biased towards the manufactured goods particularly with high technological content favouring the advanced countries at the expense of least developed countries.

When we come to S&T in particular, it is possible to enumerate a number of reasons why African countries failed to get the expected result. The major factors are lack of resources, failure to integrate macroeconomic policies to S&T supposed to support them, power conflict between S&T institutions and the various ministries, the failure to retain and motivate the scarce highly skilled manpower, the disconnect between research and industrial development, and Lack of institutional support to indigenous entrepreneurs.

The 1980s were years of industrial stagnation and even dc-industrialisation for many sub-Saharan countries. "In nineteen countries (hat is half the countries of SSA but covering much more than half the population), industrial growth was less than 2 percent per annum from 1980 to 1987; in ten of these countries, industrial production fell over this period (World Bank, 1989). For SSA as a whole, industrial production fell by over 1 percent per annum. These countries were thus moving away from the long-run goal of industrialisation and diversification, in a clear conflict with longer-run development needs (Stewart, Lall, and Wangwe, 1992).

In nearly all economies, manufacturing industry has been critical agent of the structural transformation that marks the transition from a primitive, low productivity, low income state to one that is dynamic, sustained and diversified (Lall, 1992). But in Africa, besides the very heavy indebtedness, the pattern of industrialisation was, for the most part, inefficient by every measure, highly protected, highly import dependent, with very low linkages with the rest of the economy and associated with very low levels of export.

But, nonetheless, Africans want to be emancipated not only politically but also economically. Many African authors have suggested the path of national self-reliance and collective self-reliance of Africa as a legitimate aspiration to control one’s own economic and social development. To understand this feelings one can see the African Declaration on Cooperation; Development and Economic Independence, adopted by the Heads of State and Government of OAU at the Tenth ordinary session in Addis Ababa on 25 May 1973; 32nd Ordinary Session of the Council of Ministers of OAU in Nairobi, 1979; the OAUIECA Symposium on the Future Development Prospects of Africa Towards the Year 2000 in Monrovia, 1979: the ECA/UNEP Seminar on Alternative Patterns of Development and Life Styles for the African Region in Addis Ababa, 1979; the ECA Conference of Ministers'14th Session in Rabat, 1979; and OAU Council of Ministers' meeting and the Ordinary Session of the Heads of State and Government in Monrovia, 1979.

Adedeji (1981) contends that a series of failures have amply demonstrated to African countries that, as a group and as the least developed region in the world are in a least enviable position. Co-operation with the prosperous industrialised countries based on trade and aid is not going to help them become prosperous by maintaining traditional economic patterns and dependent relationships. Particularly under the classical international division of labour whereby African states remain suppliers of basic raw materials and importers of capital, technology, technical know-how and manufactured products.

The 1980s have become the lost decade when the de-industrialisation process took place and the 1990s a decade of painful and slow recovery with the closing years of the century bringing another chain of regional wars with the consequent detrimental result to the African economy as a whole. This last thing is a clear indication that SSA needs political stability first and foremost if at all an economic recovery will be possible. It is within this context that we need to discuss the industrial technology development.

Developing technological capability is particularly meant to help in the process of industrialisation. Buying modern sophisticated machinery does not necessarily mean it will improve technological capability. These misunderstandings in the past have created more problems than it solved. For example in Tanzania the Morogoro Shoe Factory (Lall, 1992) illustrated some of the worst features. It was a project financed by the World Bank. It was meant to exploit the large supply of hides and skins to manufacture shoes for the export market. The technology used was sophisticated and beyond local capability to operate efficiently. The factory has never reached 5 percent utilisation of its capacity and the quality of the shoe was not even acceptable to local market. The choice of technology was made with the help of an Italian consultant. The project was a complete failure.

In Cote d'Ivoire, Tanzania and major areas of Nigeria, interesting facts have been observed. These countries have failed to build up local capability to initiate and manage industrial ventures efficiently without the heavy dependence on foreigners and on imports. The many inappropriate technology decisions, low capacity utilisation and the non-existence of exports were common to most manufacturing enterprises in these societies. Despite the differences in political and economic philosophy and irrespective of whether the enterprises were in the public sector, were owned by foreign ventures, were joint ventures or were privately owned, all exhibited similar weaknesses (Stewart, Lall, and Wangwe, 1992).

But, it does not mean always that the industrialisation activity in SSA has been a failure. There are instances of success as well. For example, in Nigeria we have the successful Ibru conglomerate and the town of Nnewi (see Stewart, Lall, and Wangwe, 1992). Ibru conglomerate was founded by Michael Ibru, a Nigerian entrepreneur, who pioneered the distribution of frozen fish, and subsequently moved into fishing, palm oil, citrus and pineapples production and canning, as well as joint enterprises with foreign companies in ventures including construction, brewing, and prefabricated housing. The organisation has created a lot of employment to people while at the same time it has been consistently profitable, permitting expansion into new areas. A similar experience occurred around the town of Nnewi. It is an example of local industrial development based entirely on private initiative and with no foreign investment. The area started as the main centre for the import and distribution of parts for the motor industry. Manufacture of parts followed. Technical assistance has come from Taiwan, with local engineers sent to Taiwan and Taiwanese visiting Nnewi for limited periods. There are significant, but unofficial, exports.

Zimbabwean industrialisation has probably been the most successful among SSA countries. By the end of the 1980s, the sector accounted for nearly 30 percent of GDP, with a value added of $1.5 billion. It was the second largest employer, accounting for 17 percent of formal sector employment. There has been considerable import-substitution and significant growth of manufactured export (but with some decline in the proportion exported during the 1980s). The sector showed notable diversification with significant inter-industry linkages. However, although there is relatively little new foreign investment, there is very heavy dominance of whites over ownership and management (Riddell, 1992). Another successful country is Mauritius which has developed a garment industry in the last fifteen years, which has displaced the sugar as the island's biggest export (Ghani, 1989).

While the examples of successful industrial development in the large-scale formal sector, whether owned by the state or by private enterprises, have been unusual, especially among indigenous companies, the very small-scale sector has been notably successful. According to the review of evidence presented by Liedhofm (1992), small -scale firms never account for less than 59 percent of total industrial employment, while in Sierra Leone the ratio is 95 percent. The vast majority of these firms are very small (employing five or fewer). The share of industrial value-added of firms with less than ten workers ranges from 26 to 64 percent.

The most important activity is clothing, followed by wood products, metal products and food processing. The majority of small enterprises are located in the rural areas, mostly linked, in one way or another, to agriculture. As shown by Bagachwa and Stewart (1992), The small rural enterprises adopt labour intensive technologies and produce simple appropriate products. All the studies of efficiency show that small enterprises in Africa exhibit social cost-benefit ratios that easily exceed one and are invariably higher than of the formal sector. But these goods and services are not exportable, unlike the myriad SMEs in Taiwan, we have already seen in previous chapters, which have successfully evolved around TNCs and local firms to produce for the export market, earning more foreign exchange to finance further industrial development in a virtuous circle.

On the other hand, the evidence presented by Liedholm suggests that the 'graduation' rate in African economies - the proportion of micro enterprises, which grow into middle sized enterprises - is very low in Africa. One explanation for the relatively low graduation rates in African economies is entrepreneurial deficiencies, especially marked in relation to middle sized enterprises. Another explanation is policy framework biased against agriculture that has also hurt the growth of small rural enterprises. There are many other biases in government policies in resource allocation. The credit and foreign exchange as well as trade policies and products policies have systematically favoured the large scale in most African economics (See Stewart (ed.) 1987; Stewart and Ranis, 1990; Haggblade et al., 1990; Wangwe, and Ndlela in Stewart et al., 1990).

The high degree of public ownership in African industry and other sectors is often blamed for much of the observed inefficiency. African public enterprises have had a very poor profit record in 1980. For example, the net losses of public enterprises in Niger were 4 percent of GDP, in Mali, 6 percent, while the large investments by parastatals in Kenya produced a rate of return of only 0.2 percent. Other measures of efficiency also show weak performance. For example, Tanzania public enterprises have exhibited high capital intensity and low capacity utilisation. In Ghana, public enterprises showed higher capital intensity and lower labour productivity than private enterprises. Nonetheless, there are some efficient public enterprises such as the Kenya Tea Authority, the Ghanaian Volta River Authority and the Zimbabwe Iron and Still Co. (See Berg Report, World Bank, 1981; James, 1986; Wangwe in Stewart, Lall, and Wangwe, 1992; Killick, 1978).

Friedman (1993) quoting Mazrui (1988) says that while the ancient African kings built palaces and pyramids the modern presidents erect steel mills and hydroelectric dams, the new 'temples'. This is to make his case of saying that in Congo Brazzaville, the ruling elite make these 'temples' because they are the constant source of their private wealth. A classical example of plunder of state wealth is that of Mobutu, the late ruler of Zaire and allay of the West during the cold war, which left the country in complete economic and social ruins and now in a civil war'. In the minds of some of the best Africans, the indirect contribution of the West, and particularly of France, to the private appropriation of Zaire by a military/bureaucratic clique removed much of the credibility for future policies of international co-operation (Castells, 1998). The Nigerian case is similar to that of Zaire (Democratic Republic of Congo). The successive military rule and the personal appropriation of oil wealth have destabilised the country. Now, after the sudden death of Gen. Abacha, the country seems to have rediscovered the road to democracy. But the economy of the country is in total ruins and the Nigerian people are poorer now than at independence despite its rich oil deposits.

If you take even Kenya, the more economically stable country in East Africa in relative terms, the political elite has extensive business interests and it is common place that political positions are used as a base for successful economic activities (Bigsten, 1993)" One of the major constraints on growth in the African economies is the unwillingness to undertake reforms that threaten the entrenched elite. In Kenya, indigenous business class and multinational firms have prospered behind high import barriers, making it possible to earn high profits by selling on the home market because they have connections with political elite (ibid.).

Tribalism or ethnicity per s6 is not a reason for political instability in the African continent but it has been politicised as a means to control political power and through this the economic resources of the country within the above context. The ethnic differences that are at the forefront of Africa's political scene today are politically constructed rather than culturally looted (Castells, 1998).

It is believed that direct foreign investment (DFI) would enhance industrial efficiency and would also help the capital account of the balance of payment, thereby relieving the chronic foreign exchange shortage. It would also become a vehicle of technology transfer. However, the past record of foreign investment, do not show a markedly positive record of DFI in African economies [see Cockcroft, Mytelka, Ohioehenuan and Poloamina in Stewart et al (eds.), 19921. But DFI has been limited to the extractive industry or primary products. In general, it is possible to say that DFI in SSA is very small. In the First African regional Conference on Science and Technology (1995) the DFI in Africa was assessed to be comparable to the amount attracted by Singapore and concentrated in a few countries and in a few sectors such as oil and mining. IT has been noted that NIEs are heavily relying on FDI to strengthen their technological capacity. The problem with Africa seems to be the result of mainly the political instability, even though, recently there is growing market openness and better and more attractive policies to potential investors.

Incentives do have an important role to play, directly and by influencing the development of capabilities. It is the interaction between incentives, capabilities and institutions that fundamentally determines industrial efficiency. While the unfavourable external environment handicapped industrial effort, the major responsibility for poor performance in large-scale formal sector industry lies with failures with respect to each of these elements, in incentives which have discouraged efficiency that resulted in deficiencies in institutions and in capabilities.

On the other hand, because of the political problems that would arise from excessive reliance on DFI, joint ventures are often suggested as a way of gaining the benefits of DFI, while reducing foreign control. There is an optimistic scenario that joint ventures will gradually transfer entrepreneurial, managerial and technical functions to the local partners. This would, first, increase local capacities, and then, also the bargaining power of the local partner, which depends, among other factors, on local managerial and technical capability [see Barba Navaretti, Cockcroft in Stewart et al., 19921. But there is no evidence that joint ventures perform any better than MNCs in terms of technology choice or efficiency, nor, however, that they perform any worse.

African governments have spent large sums of money on universities, national scientific Research Councils or Science and Technology Commissions that have confined themselves on high-powered research and manpower training only (UNECA, 1991). These very institutions were supposed to be the engine of the whole national development, by isolating themselves from the entrepreneurs, bankers, lawyers and educational institutions, i.e. from the very society they were supposed to lead, became ineffective as agents of socio-economic development. But there are few successful results in developing new varieties of rice and wheat, in the production of compost manure, and early diagnosis of certain diseases (UNESCO, 1988, p16).

A lot remains to be done to enable SSA countries to adopt and implement measures for the development of an adequate technological base. An appropriate application of S&T with a view to ensuring an integrated development process with strong inter-sector linkages is a must to start with. In other words, co-operation arrangements between universities, research institutes and enterprises must start. In the process of creating the right environment of intersector co-operation, the government's S&T body, through its policies, plays a very crucial role. This is particularly valid to all developing countries.

CASTAFRICA II recommendations are widely held in Africa, and one of the views they reflect is that the basic problem to be solved is that of an under-supply of adequate science and technology (Hill, 1987). Improvement of capacity to manage technology, and to make and implement effective policy for it, requires the development of better diagnoses of skill deficits and institutional bottlenecks in policy management, policy processes and management traditions in Africa. African S&T policy makers have been more successful in thinking about how to organise the supply of S&T than in thinking how to organise the demand for it (Davis, Tiffin and Osotimehin, 1994). That African countries need to work on the demand-pull aspect of innovation is also emphasised by UNECA report (1991).

Therefore, to promote S&T for industrial development in Africa, the supply and demand side of the equation need be synchronised. The point made by Vitta (1990) is still valid. He suggested four sets of constraints that must be rectified if technology policies are to be made effective in Africa. Implicit technology policies must be made explicit; 'informal management' which he equates to tradition and corruption should be replaced by professionalism, weaknesses in institutions for policy management need be eradicated, and content of technology policies should be relevant and clear. Africa need to wake up to address these issues now more than ever because the danger of being at the margin of the global economy is increasingly threatening and closer than over. Politics as a means of control of economic resources for personal, family or ethnic group's advantage should be totally rejected. Political stability should be given priority with greater trust and co-operation among African countries in order to make unnecessary the recurrent arms race and conflicts, only then, one can really think and work on real development issues. Otherwise, all the macroeconomic development policies and activities and sound S&T policies for industrial technological development that is produced every year in international conferences or in government planning offices (to redress the endemic poverty and backwardness) become a mockery to our intelligence and effort.

8

8. IT in SSA Countries

8.1 Introduction

In this chapter, we will consider the experience of SSA countries in IT policies and management. Computers, particularly the microcomputers, are penetrating the SSA countries. How are these countries coping with this new phenomenon? Of course the SSA countries have their peculiar situation with regard to IT use and diffusion. It is very relevant at this stage to capture this peculiar experience in order to learn how best to cope with this new and pervasive phenomenon known as the 'micro-electronics revolution'.

8.2 Environmental context

We are on the verge of entering the new millennium. IT has become the norm in the advanced countries. Even the NIEs, particularly those of the South East Asia, have done a lot of "catching up" in IT. They have become heavy consumers of it and to some extent also are participating in the supply of it. At times their being late comers have given them the opportunity to be among the early adopters of IT. These countries are cited as good examples of leapfrogging in information technology. While SSA countries seem to be slow in reacting to this revolutionising technology, even though microcomputers are coming in significant number. The diffusion seems slow and unsystematic and changing the economic landscape of Africa may take years. But there is an opportunity to those who are quick to invest in IT in a way that can expand their capabilities in education and training as well as work.

Ethiopia has been mentioned as the first African country to acquire a computer in 1960 (Afrique industrie, No. 372, I July 1987). But there are evidences that as far back as 1952, the Governor General of the French Equatorial Africa (FEA) established a data processing workshop with traditional IBM equipment for the processing of civil service payroll, the FEA customs statistics and other statistical data (htlp://www.sas.upenn.edu/African-Studies/ECA/nan2a.html). Since then, there has been progress. But, by world standards, Africa is still in the initial stages. The total present market for the IT products in Africa has been estimated at no more than 2 billion French francs (less than $400 million), about one thousandth of world market ("Marches; l'Afrique est-elle dans la course?" Jeune Afrique, No. 1535, 4 June 1990). This contrasts with an Africa share of world industrial production of between 1 and 2 percent.

World Bank financing and assistance in IT have become quite pervasive in Africa, and projects with IT components are increasing in scope and complexity. A recent study found that significant IT components were present in over 90Vo of all Bank lending operations in Africa in fiscal year 1990 (Hanna, et al., 1990; Hanna and Schware, 1990). Perhaps more significantly, the volume of Bank lending for IT has been growing since l98l at an average annual rate of nearly 307o. While IT is only 3Vo of a typical project's cost, it can be as large as 6OVo and total expenditure on IT are quite substantial. IT lending in the Bank projects in Africa in 1989 was US$180 million, twice the level of 1986. The African continent accounted for almost one-third of all IT lending by the Bank in 1989, which amounted to US$570 million (Hanna, 1990).

The first computers were installed mainly in the headquarters of the ministries (typically Finance and Planning), in central statistical offices, and in the major public utilities (railways, electric power'). The use of computers often was mandated to facilitate the management of a single project or to be used by a technical assistance consultant. Gradually, the establishment of formal multi-year development plans, and the need to manage data-intensive tasks such as treasury accounting, tax and customs, the civil service payroll and the national census, started to make demand of computing facilities. Aid agencies and foreign companies provided technical assistance and computer vendors suddenly took an interest in Africa.

Taylor and Obudho (1977) tell us that at the beginning there were relatively few Africans trained in statistics, computers and information systems, these functions were staffed mostly with expatriates funded from multilateral and bilateral technical assistance programs. Frequently these expatriates introduced computer-assisted tools that focused narrowly on the implementation of isolated segments or tasks of a project, without adequate attention to how the segments might subsequently be integrated or how the project overall might be sustained. All too often, IT was inappropriately introduced and used, and concepts and methodologies were transplanted without being adapted to the African institutional environment.

In the 1980s, as part of structural adjustment programs and with the encouragement of the Bank, many governments started to introduce computing facilities. As a result, IT became more widely diffused. But, in 1985, it was estimated that nearly half of the information market in Africa was provided by foreign aid (African Business, October 1985).

That being how computer technology came to Africa, the communications infrastructure was still is. Africa has very low level of telecommunications. The number of telephones in SSA countries is 14 per 1000 of the population, but South Africa alone has 100 per 1000 of the population. The low-income countries' average is 11 per 1000 of population (World Bank, World Development Report 1998/99). Even though improvements are made, SSA countries, excluding South Africa, are still way Iagging behind the rest of the world.

The pace of restructuring in the African telecommunications sector has been accelerating since 1990 as telecommunications operators established as joint stock companies, regulatory agencies created and private participation in the cellular industry is growing. For example, the national telecommunication operator in Guinea was partly privatised in early 1996. In Cape Verde, the government announced a tender for 40 percent of the national operator in 1995; in Ghana, there are two and soon to be three cellular competitors while Tanzania has issued tenders for additional cellular operators. Some 23 African countries had cellular systems in operation by the end of 1995. A significant development is the planned partial privatisation of incumbent operators and the introduction of second fixed-link operators in Ghana and Uganda, which was announced early in 1996 (ITU, African Telecommunication Indicators 1996).

Africa is slowly getting connected to the worldwide Internet Network. In 1994, the first SSA countries were connected and by December 1995, 16 African countries had direct Internet connectivity. South Africa has one of the world's highest densities of Internet users (ibid.). By May 1999 there were only three countries without full Internet connectivity: Eritrea, Congo, and Somalia (http://www3.sn.apc.org/africa). All but Somalia will have one shortly. But it should not be a difficult thing to set up a full Internet connectivity in Africa with the many International Agencies ready to help with funding and expertise. This will be elaborated later, in the section on institutional capability also.

Internet access in Africa has been largely confined to capital cities, although a growing number of countries do have them in some of the secondary towns. Most African capitals now have more than one Internet service provider (ISP) and in early 1999 there were over 300 public ISPs across the region. Seven countries had l0 or more ISPs - Egypt, Kenya, Morocco, Nigeria, South Africa, Tanzania and Zimbabwe -

while 20 countries had only one ISP. Although Ethiopia and Mauritius are the only countries a monopoly ISP is national policy, i.e., the private companies are barred from reselling Internet services, there are other countries in which this practice still continues, predominantly in the Sub-Saharan African where markets are small (ibid.).

In some countries the public telecom operators have made a special policy to provide local call Internet access across the whole country. To do this, the local telecom operator establishes a special 'area-code' for Internet access that is charged at local tariffs, allowing Internet providers to immediately roll out a network with international coverage. With the massively reduced costs for those in remote areas that this provides, it is surprising that so far only 13 of the 53 countries have adopted this strategy - Burkina Faso, Ethiopia, Gabon, Malawi, Mali, Mauritius, Mauritania, Niger, Senegal, Chad, Togo, Tunisia, and Zimbabwe (Jensen, 1999). It is difficult to measure actual number of Internet users, but figures for the number of dialup accounts provided by ISPs in Africa are more readily available, the estimate of which is more than 500,000 subscribers with an estimated number of hosts at about 25,000. This represents about 0.06% of the world's 43 million hosts (ibid.).

SSA cannot fully exploit the opportunities offered by IT with such low level of telecommunication service infrastructure. Isolated microcomputers, no matter how large their number is, cannot bring the required productivity and efficiency. At the same time telecommunications infrastructure requires substantial capital investments which is in short supply in all African countries, particularly some are heavily indebted. It is a real paradox, therefore, to ask for more investment in telecommunications infrastructure when there are some more pressing needs like the debt servicing, and feeding the population. Really hard times are ahead of Africa. The immediate benefits have to be traded off with the long-term benefits. But Africa is full of contradiction, there are many luxury items consumed by African countries like cars, VCRs etc. by the affluent few. Telecommunications services and computers, on the other hand, should be considered as necessities to make SSA countries' economies more efficient and the integration with the world economy possible.

The global restructuring in the telecommunications market has some hope for Africans. The trend is that the national telecommunications service companies are progressively leaving place for the few very large international telecommunication carriers, which will control the supply of the world telecommunications services. This means that each country need only open up their local market to such corporations to get the benefit of an efficient telecommunications services and get connected to the world. The mergers in the international telecommunications companies in the world may definitely push African countries to follow suit and open up their markets. This may give way to better telecommunication services and at cheaper than the prevalent prices, which are in general higher than in the developed world.

At this point, it is relevant to consider the thoughts of Castells (1998) in his 'End of Millennium' book where he exhaustively discusses the 'information age' and the 'networked society' with the implication to what he calls 'the rise of the Fourth World'. These social groups are those excluded by the information society or networked society, and SSA countries are one of them. With the exception of selective integration of small segments of African capitals, affluent markets, and profitable exports into the global networks of capital, goods, and services, most of the economy and the overwhelming majority of the population are left to their own fate, between bare subsistence and violent pillage. Globalisation of world economy may not necessarily bring benefits to SSA because it is steered by profit motives. The eradication of poverty or ignorance under which their peoples are chained is not the problem of TNCs that dominate the global markets. Only the people that have their life at stake can do something about it.

Therefore, given the environment of the new global economic older, strong leadership is required from governments in the SSA countries to use the powerful tool of IT to solve their social and economic ills in partnership with their people and international community. This will require a new social and economic philosophy than the crude capitalist system we have around us. Castells (ibid. p.161) calls 'black holes of informational capitalism' to the rise of inequality, social polarisation, poverty, and misery in most of the world. We agree with the warning he gave that, 'unless there is a change in the laws that govern the universe of information capitalism, since, unlike cosmic forces, purposive human action can change the rules of social structure, including those inducing social exclusion. There will be no escape from pain and destruction inflicted on the marginalised' (ibid. p.162).

8.3 IT policy

It is very difficult to speak about IT policy and management in SSA countries becau.se it is a new phenomenon. It is true that computers are coming to these countries, particularly the microcomputers, but nothing systematic is yet done, like national IT plan, to follow an efficient and effective path of diffusing the use of computers for economic development. May be African governments are not sufficiently aware of the full potential of IT or they consider them as too advanced and costly to be interested in them. But one thing is for sure that even the SSA countries cannot afford to ignore them. The future is of information technology.

Vision and goals

It is clear that while African countries have started to make investments into computer and related technologies there is a dearth of underlying computer technology, which hardly rises above the basic level. The effective application of IT, therefore, has hardly begun. But since the uncontrolled introduction of IT can be as harmful as the absence of this technology, it is important for nations to analyse critically their current status in IT, in terms of national objectives, the resources required and costs (Zwangobani, 1988:156).

SSA countries have one simple and grand vision: to have a decent living standard for their people. Industrialisation and the underlying technology transfers were all meant to achieve this vision. IT, as the new pervasive and revolutionary technology, is at the heart of the current industrialisation experience in the world. If the first wave of industrial revolution has left Africa out, we cannot let this new industrial revolution based on IT pass it by. It is within this framework that a national IT policy should identify the requirements, make provision for' necessary resources and promote the effective use of IT for the betterment of society. This gives us more reason to find the right place for the national IT Plan within the national development plan.

Therefore, the national socio-economic development plan should be the basis for the setting of technology priorities. All over the world, the significance of 'microelectronics revolution' has been recognised and given due attention. SSA countries cannot afford not to list it in their priorities for their vision has less chance to materialise without it in the 2l't century. Priority areas should be allocated adequate resources to ensure success. This process normally leads to the sector development of IT, which requires co-ordination to avoid duplication. On the other hand, experience has shown that a national policy on IT is a major determinant in developing and improving IT itself. It is with this in mind that we are looking for the vision and objectives that SSA has to achieve with IT.

Let us analyse what could be the long-term objectives that SSA countries should look for to achieve. At the basis of computing facilities acquisition made by civil services, or individual education and research institutions, or international agencies, or non-government organisations or individual enterprises in the SSA countries, we usually find one or more of the following implicit or explicit objectives:

1. To help produce goods and services that can compete in the international market;
2. To get connected with the world information highway;
3. To make most of the internationally available scientific and technological know-how for development;
4. To educate and train people;
5. To help improve the national health management;
6. To improve the efficiency of public agencies management and services;
7. To monitor and control pollution, and manage the environment for sustainable economic development:
8. To help in the cultural development of the country.

The above objectives are emphasising the role of IT as an infrastructure. This is true of all developing countries in general and in particular of SSA countries. It is logical that at the initial stage of industrialisation countries are mainly users of IT than producers. If they succeed in the process of industrialisation, at a later stage based on their comparative advantage, they may pass to the advanced stage of producing and competing in the international market in the supply of IT products and services. But that is far from the sight now.

There are now attempts to help African governments come with clear vision and national IT Plan such as the one given by the African Information Society Initiative (AISI) to support and accelerate socio-economic development across Africa (see Appendix 5). The latecomers like Eritrea can benefit from the study and recommendations of such initiatives and have the chance to use it as a checklist for the future national information and communications infrastructure plans.

IT policy

A policy, that clearly recognises the strategic importance of IT and tries to use a national IT plan for introducing and diffusing the right kind of these technologies, is found nowhere in the SSA countries. This is because there is lack of skilled manpower, there are other more pressing needs to attend to and, of course, there is a severe foreign exchange shortage to make adequate investments in IT. Nonetheless, the lack of awareness of the potential benefits of IT to the economy, among the leaders of these countries, is not to be excluded.

Even with the necessary awareness, the task of introducing, diffusing, and integrating IT into the socio-economic fabric of the SSA countries would be very difficult and, if successful, a matter of a generation's time because of the very low literacy levels. Assuming the necessary capital investment is available, to educate and train people and allow them to have enough experience to build all the necessary know-how and skills in IT requires time.

One is tempted to give up by looking at the sheer amount of money required to develop all the infrastructure facilities for IT before it could be used and exploited to make a real difference in the economy. But let us think of the money paid for debt servicing to the first world. Add to it the money African countries spend for their armies and the money that ends up in the pockets of corrupt government officials, it would not be difficult to figure out that the necessary money is there but not used properly. Of course the issue of debt cancellation must be accepted by the international community if at all a real development is to take place in Africa.

Is there any serious attempt by SSA countries to shape the IT policies and plans to bring about the much desired socio-economic development vision? Under the general title of 'National computer centres' a wide variety of different bodies can be found in African countries. Often, the national computer centre will represent the only major initiative so far taken at the national or government level to encourage computing and the diffusion of skills. The terms of reference, mandates, responsibilities and the scale and scope of activities varies very much. In some cases, these institutions are at a formative stage and their role is confined to the preliminary formulation of national IT policy, sometimes being essentially the secretariat of a national committee dealing with this subject, or having some co-ordinating function (see Gahan, 1992: 2O). The tasks of national centre may include formulating national IT policy, developing IT plans, implementation of selected aspects of IT plans, systems development and implementation, usually for the public sector, maintaining a centralised computer service, investment promotion, providing training in IT skills, approval of imports of hardware and software, drawing up import guidelines, and standard software development.

Country examples include Congo (Republic), for instance, where there is a body that deals with IT co-ordination. In Guinea, there is the CNIG. In Mozambique there is a special commission on IT founded in 1980 but it has not yet published a national policy. There is however the body CTD for IT co-ordination. Nigeria has the CCC for IT co-ordination (Le courrier, No. 113, January/February 1989). More elaborate structures are also found, notably in Senegal and C6te d'Ivoire, for instance. C6te d'Ivoire has a national IT commission and executive body (Computers for industrial management in Africa; the case of Cote d'Ivoire, PPD. 154,2l March 1990). Ethiopia has a national Computer Centre under the national Science and Technology Commission (Computers for industrial management in Africa: the case of Ethiopia, PPD. 176, 18 September 1990).

IT has been introduced into Kenya's information systems and services without specifications of overall national developmental and information needs to be achieved. Policy and decision makers have further complicated this situation. They have often concentrated on the procurement of hardware only, without consideration of human resources, for software development and/or adaptation of technology. Lack of co-ordination in the selection and procurement of information technology has reduced the possibility of co-operation needed in the development of national information resources as well as the chance of co-operative efforts to facilitate information exchange at national, regional and international levels. To have an effective information policy there is a need for an effective national IT policy (Kenya: national information and Informatics Policy, 1988). Information and the knowledge that comes from it are a very critical factor in the national development of any country. IT becomes a very powerful tool in the management of information resources if properly designed and used. Unfortunately many SSA countries have a very poor information management capability.

Zwangobani (1988:164) hits a very important point while discussing the performance of the inter-ministerial committees, usually established to recommend on IT policies. First, these committees are often dominated by people without IT skills. Almost all of them seem to have an ephemeral existence. The high staff turnover in government does not explain this phenomenon. In Kenya, Tanzania and possibly Zambia, these committees were established, met for some time and then withered away. This may be another indication of the lack of commitment to IT on the part of non-IT officials. Equally it may be an indication of a lack of commitment to the purposes for which the committees were created, for any government committed to a set of goals would surely set up viable machinery to achieve and maintain them. But, given the tendency to use the main IT authority (e.g. government computer centres) as both the main policy- implementing body and as a resource centre, the manager of the government computer establishment is in a pivotal position and could help in bringing the commitment missing in the ephemeral inter-ministerial committee. He is able not only to influence policy formulation and its implementation, but also to catalyse the process of policy formulation (ibid.). It follows that the experience, training and drive of this individual (or the team) can have an important bearing on the pace of events in IT in the public sector and perhaps in the country as a whole.

It is known that the import policies adopted by a country will have important effects on the spread of technologies within the country. Sometimes these effects are unforeseen, and they may be quite opposite to what the policy maker intended. In absence of explicit IT policies, duties, tariffs, sales taxes, import/export licences and foreign exchange permits can work as the implicit policies. For example, in 1985 for 24 African countries the average rate of duty (which sometimes included fiscal tariffs etc.) was over 34 percent (Survey of government policies in informatics, UNIDO/IS.526, 4 April 1985). By contrast, developed country tariffs on computers are very low. The most-favoured nation tariff rates on computer central processing units in 1987 were 5.4 percent for the European Community, 4.9 percent for Japan, and 4.3 percent for the United States of America. Tariffs on computer peripherals and computer parts were of a similar order, although some peripherals attracted duties of up to 13.8 percent in Japan (Kostecki, 1989). Given the intense levels of competition between the three, the low rate of duty is striking. They of course partly reflect the general openness of the world trading system, but also the strong demand for such products among industry and the services sector in developed countries.

The choice of such high duty levels in African countries, says Gahan, may have been made with one or several objectives in mind, such as to discourage foreign exchange expenditures in general; encourage capital expenditures on other types of machinery; increase government revenues; and encourage local manufacture of computer equipment.

However, analysis has shown that computer use is highly sensitive to computer price, with a price elasticity of about -1.5. This means that a policy that doubles price will reduce usage by two thirds. Protectionist policies which attempt to foster the domestic production of hardware will do so at the cost of significant reductions in the application of computers in the national economy (Flamm, 1989).

In Ethiopia, a corporation or factory wanting to acquire a computer must obtain Ministry of Industry approval before seeking foreign assistance or requesting a foreign exchange allocation [Computers for industrial management for Africa: the case of Ethiopia" (PPD. 176, 18 September 1990)1. In Ghana, a manufacturing firm has to apply for an import licence from the Ministry of Trade (on the recommendation of the Ministry of Industries, and Science and Technology). These procedures are not as time-consuming as they used to be, but they are now a first step before competing in an uncertain foreign exchange auction, where a full deposit in local currency is necessary. Customs duty and sales tax on computers and electrical and electronic equipment generally are fixed at 50 percent of the c.i.f. value. Importers with their own foreign exchange resources are reported as being charged an additional 50 percent (Ayiku, 1989). In Zambia, by contrast, trade policies for electronics are reported as being progressively made more stringent. Except for government and structural needs, which are given special consideration, all other users have to obtain permission to import and also queue up for foreign exchange. Data processing machinery attracts a 30 percent ad valorem customs duty and also an import sales tax of 25 percent, making an effective landed value 55 percent above the import value. To this is then added a local sales tax of 10 percent. Imports of automatic data processing equipment amounted to $3.1 million in 1986 (Wadia, 1989).

Today many African countries are asking more IT lending to improve performance an4 productivity. Still, only a few countries seem to have policies and environments that promote widespread and effective IT application in all sectors of their economies (Jules-Rosette, 1986) - IT policies in Botswana follow a laissez-faire approach (Datta, A., and Baffour-Awuah, M., 1988). In other words, the decision whether or not to make use of an innovation is left mainly to individual organisations. But the absence of a national policy in Botswana is creating some problems such as the proliferation of incompatible brands. For instance the Geological Survey Department, in 1988, had ten computers of four different brands" There were five machines from one brand, but all are of different models. But the government in Botswana is cautious about the adoption and application of innovative IT techniques. Policies governing the activities of various ministries and other agencies of the Government in the acquisition and use of both hardware and software are monitored by the Computer Steering Committee which also oversees the standardisation of public sector database systems as well as staff training. A good IT policy would ensure that selected hardware and software were used rationally, thereby resulting in considerable economies.

A problem such as that of education and training will be subject also to frequent redefinition, as a consequence of technological change. As noted above, the rapid changes in technology that have taken place in the world of computing mean that late comers have had an opportunity to skip some of the less efficient stages and to move directly into more advanced fields, we refer to this as leapfrogging. The reduced costs of equipment and the increasing user-friendliness of software means that the possibilities of using the technology in a productive way have increased. But there are several problems also. The personal computer is leading the computerisation process in Africa. Personal computers can be relatively easily maintained. However, maintenance from the manufacturer is less likely to be available (Afrique industrie, No. 390, 20 April 1988). Thus, the skills required may have decreased in level, but the volume required has increased very much. Repairs and maintenance of thousands of personal computers is not the same as repairing one or two mainframes. Therefore, national IT policies need to take care of the whole package that concerns the process of computerisation, if it is going to be effectively and efficiently used.

There will remain also the question of whether there are specifically national or regional solutions to be sought and roads to be taken. Some opinion would suggest, for instance, that Africa should turn to software specific to its countries, and there should be computer service companies, for which a market exist (Afrique industrie, No. 390, 20 April 1988). But the market may be in many cases a potential one, needing many steps before it becomes a real consumer market, ready and able to pay for hardware, software and services to meet specific requirements. Again, the idea of software production for local requirements has to be defined more precisely: there are undoubtedly specific language needs, or, for instance, accounting needs resulting from particular social security or taxation systems, and these can and should be met by specifically tailored software. But the standard solution will usually be quicker and more appropriate: a straightforward database or spreadsheet application will meet the majority of requirements and will be a great deal cheaper.

The evidence so far explored show that SSA countries have a long way to go in terms of organising themselves better to exploit the opportunities offered by IT to help them increase their international competitiveness. National IT Plan would increase public awareness and give more sense of direction and co-ordination and the AISI expertise can be of great help (Appendix 5). Therefore, without assuming that everything can be accomplished with good policies and plans, the effective use of policy instruments can accelerate the learning process and these countries have to learn how to best use them to achieve their development goals.

8.4 Institutional capability

The dissemination of IT requires the development of an adequate institutional support. There are many aspects to this, ranging from setting standards for the procurement and use of IT to building indigenous IT production capability. Always essential, however, ale modern telecommunications and widespread diffusion of computers, In general, telecommunications networks and services in Africa are grossly inadequate in terms of unmet demand, low penetration nation-wide, and poor quality and reliability of service.

In a few African countries the importance of telecommunications for the wider development of an industrial society, which allows a full use of the information processing capabilities of computers, has already been recognised (Gahan, 1992). Cote d'Ivoire has sytranpac, Cameroon has COMPAC, and Gabon has GABOPAC and that means they already have or soon will have public data networks of the Transpac type (Afrique industrie, No 379, 5 November 1987). In Nigeria, the oil companies are at the forefront of network development. Shell have its own network based on leased lines. A subsidiary of the Nigerian National Petroleum Company has installed a network said to be the largest in Africa (Computers for industrial management in Africa: the case of Nigeria, PPD. 126, 10 July 1989).

With regard to telephone density in Africa, there are only 14 telephones per 1000 people in SSA. In general, the quality of service in Africa is poor, with local call completion rates of less than 30%, compared to more than 70% in OECD countries. International call completion are even worse, often below 20% (Sanders, warford, and wellenius, 1983; Lomax, 1990). It is difficult to have a clear picture of the number of personal computers per 1000 people in SSA, even the recent World Bank world Development Report (1998/9) does not give one. But the figure for the low and middle-income countries is 8.7 computers per 1000 people and SSA countries do have considerably lower figures than that. On the other hand, the number of Internet hosts for SSA is 2.03 per 10,000 people. But remember that of these only South Africa has 30.67 Internet hosts per 10,000 people.

Investments in telecommunications facilities in Africa grew between 1990 and 1993. However, like revenues, investment declined in 1994 by l9ok. Around 60% of investment was generated from internal resources or self-financed. This is relatively higher proportion compared with other developing countries regions, suggesting a lack of capital from other sources. Multilateral assistance, although in decline, accounted for a further 20% of telecommunications investment while the remainder came from bilateral and other sources such as grants, reserve drawing, and commercial lending (ITU, African Telecommunications Indicators 1996).

As for the gap between Africa and the industrialised world, computer spending in Africa in 1988 averaged 0.34Vo of GDP, compared with 1.47o of GDP in Italy, and 2.5Vo in the United States (Africa File and ISPA Nord/Sud, 1991). On average, spending on computerisation – as a percentage of GDP - is six times higher in industrialised countries than in Africa. Investments in IT tend to stimulate a supply respon.se from private industry and also serve to catalyse complementary investments in terminals and computer equipment. The "gap" serves to illustrate the extent to which industrialised countries have become advanced users of IT and suggests that African countries still have significant requirements in terms of IT catching-up.

A number of large firms are directly present in some African countries, although coverage is far from complete. Thus, for instances, IBM has agencies in its biggest markets: Cameroon, Cot6 d'Ivoire, Morocco, Senegal, Tunisia and also Algeria. In 1989 IBM sold 6,000 personal computers and about 200 minicomputers. However the turnover of IBM in Africa is only 60 percent of that in Portugal. Bull and Unisys are important also (Marches: l'Afrique est-elle dans la course? (Jeune Afrique, No. 1535, 4 June 1990). IBM started representation in Uganda through Business Systems Limited in late 1980s (Irvian, 1989). Computer-land had four franchises in Africa, Cameroon, Cote'd'Ivoire, Gabon and Senegal in 1987 (Afrique industrie, No. 379, 5 November 1987).

Kenya has many dealerships but it has been the focus of direct action by major manufacturers, whose involvement is in the form of subsidiary companies, such as ICL Kenya and NCR Kenya (Computers: making a mark on man's activities, The Weekly Review, I1 March 1985). In Zambia, it has been noted that the market for computers is much skewed. A survey of computer usage in late 1986 noted that of a total 116 computer companies covered in the survey, the top two had supplied 97 percent of them (Kelly, 1987). In Zimbabwe, in 1988, C.F.Tulley Associates had a staff of more than 300 and franchises for Goupil, Epson, Isotimex, Ferranti and Compaq. It also provides regional support for Data General in Eastern Central and Southern Africa (African Business, April 1988).

The question of second-hand equipment would bear closer examination in the African context. Technological change is so rapid that in developed countries perfectly usable equipment is often described obsolete. In some cases the opportunity is being taken to export it to developing countries rather than scrapping it. There are market institutions to take care of matching the supply and demand of second-hand technologies. For instance, the systems of "cartes grises" for the Ministry of Transport in Benin has been computerised with (second-hand) IBM equipment by the company Paris Computer Exchange, which specialises in the sale of second-hand computer equipment and services (Jeune Afrique economie, No. 1 10, July/August 1988). In other cases proximity to a more advanced computer market of itself does facilitate such transfers. For example, 80 percent of the installations in Botswana were ex-Johannesburg, in 1986 (Zimbabwe special report, South, No. 70, August 1986).

What are the major obstacles to increasing activity on the part of computer companies in Africa? Clearly the most important obstacle was currency restrictions and payments difficulties. This was followed by a lack of demand for computer products. The other obstacles were inadequate telecommunications, non-tariff barriers, lack of suitable local agents, and lack of market information. The remaining possible obstacles were unreliable electricity, unsuitable climatic conditions, low cost producers' competition and language difficulties. Adaptation of products to the African markets has taken place in certain cases, notably in software and in services. For both of these commercial practices were the commonest cause of adaptation, followed by language. Hardware changes were occasioned most frequently by the power supply followed by operating temperature and humidity. Other causes for adaptation cited were altitude, packaging, keyboard cables and local telecommunications requirements (Gahan, 1992).

The role of official development assistance in the development of computing in Africa is a significant one, although there are some grounds for believing that it is largely an unconscious one. Many projects for improved public administration involve the computerisation of information systems. Equally, there have been a number of activities targeted at the development of human resources in the IT field. For instance, significant training is provided in the United Kingdom of Great Britain and Northern Ireland by industry. Students are sponsored by the British Council and the Overseas Development Administration on courses run by manufacturers and training companies (Information systems training and developing countries, Proceeding of a workshop, British computer Society, Developing countries Specialist Group, London, 1989). A Wang regional sales director is quoted as saying: "half the African market is someone's foreign aid" (African Business, October 1985).

Today, at the end of the millennium, a large number of international agencies are funding and helping to overcome the connectivity problem of SSA countries to avoid the marginalisation from the global economy and international community. Internet connectivity in Africa is slowly progressing. There are a number of international agencies and organisations involved in Internet initiatives (see Appendix 6). But years will pass before we could have the evaluation of their performance, as this is a recent phenomenon. For example, USAID Leland Initiative Project is an initiative by US Government. It is a $15 million project in a five-year time to extend full Internet connectivity to 20 or more African countries in order to promote sustainable development (http://www.info.usaid.gov/rcgions/afrlleland./project.htm). Similarly the Dutch initiative to help information and communications technologies development in the developing countries has been launched in 1996. The International Institute for Communication and Development (IICD) has been, in fact, established by the Netherlands Minister for Development Co-operation Mr. Jan Pronk for such a mission. In short, the major activities of IICD will be to identify the demand for ICT applications in developing countries and to find the right supply of ICTs available in advanced countries to match them (information@ iicd.org).

As we have seen, a lot remains to be done to develop the required institutional support to diffuse information technology use for the SSA countries to make a real difference to their economics.

8.5 Human capital formation

We have already seen in the previous chapter that the human resource supply situation in African countries does not look encouraging. Human resource in IT is not an exception. It is even worse, given that it is relatively new to Africa. System analysts are either difficult or impossible to find. The .situation with respect to the supply of programmers is better than that for systems analysts. For operators, the supply situation is even better. In-company training, computer manufacturer or supplier training, and universities are the main source of trained computer staff of all types. However, the distribution of training sources differs sharply once the total of computer staff is broken down into systems analysts, programmers, and operators. Systems analysts are predominantly university-trained or trained by the computer manufacturer of supplier, with in-company training and technical qualifications being infrequent. Programmers also have preponderantly university qualifications but in-company training and technical qualifications are more frequent than are computer manufacturer or supplier training. In contrast to this, operators have in-company training as their most usual training source, with computer manufacturer or supplier training being second. Fairly few have technical qualification or university qualifications (see Gahan, 1992).

A quick overview of IT training in SSA can give us an understanding of the efforts made. In Botswana there are commercial schools (African Business, June 1988), In Cote d'Ivoire there is a training centre in Abidjan for officials. No fewer than 95 percent of analysts/programmers and 55 percent of software engineers are nationals (Afrique industrie, No.386, 20 February 1988; No.390, 20 April 1988). In Gabon, the institute African d'informatique provides training in IT on a regional basis (le courrier, No. 113, January-Februaryl989, p. 54). In Kenya training is provided by Kenya Polytechnic, with a three-year diploma course which includes industrial experience. The University of Nairobi Institute of Computer Science has a postgraduate course. About 20 schools have computers with at least three using them in teaching (African Business, June 1988). In Nigeria, at least 26 firms undertake training (Okoye, 1989). In Senegal, there is a Centre de formation a la microinformatique de Dakar. This is in connection with the chambers of commerce and industry in Dakar and Le Havre, the latter having the Centre Normand de rechrche en informatique (Cenori) (Afrique industrie, No. 390, 20 April 1988). In Sierra Leone, the Institute of Public Administration and Management at the University of Sierra Leone provides training in IT, based on the realisation that accounting and computer could not be treated as independent subjects (Computers for industrial management in Africa: the case of Cote d'Ivoire, PPD. 154, 21 March 1990).

Much training is carried out directly by the manufacturers of computers or their agents, usually of customers or their employees. ICL, for instance, has training centres in Egypt, Kenya, and Zimbabwe among other countries. Where possible it arranges for courses to be held in the countries concerned but many employees and customers also go to ICL in Britain, perhaps as many as 1,500 from Africa each year (Hutchinson, 1987).

SSA countries have a very serious problem with regard to IT skill shortage. The existing institutional capacity to develop and train highly skilled IT manpower is insignificant. What is available is mainly geared towards the operational skills. This shows again the failure of SSA governments to take the necessary action to build the necessary critical number of highly skilled IT professionals if any real exploitation is possible of this revolutionising and pervasive technology in the near future. Buying computers and more computers, as if it were an ornament, would mean nothing to the ailing economy and the poor civil service administration. African systems analysts and designers, networks experts, communications experts and hardware engineers are a priority list for those who want really the productivity that can follow a judicious use of IT. Otherwise, it all amounts to 'put the cart before the horse'.

It is clear that systems analysts and designers, and programmers are in short supply in Africa. But at the same time, the Bank lending finding suggests, the demand for more IT is obvious. Therefore, before embarking into any serious project of computerisation process, Africans should develop a critical mass of IT professionals and governments should lead in such endeavour. This should be integrated with the national human resource development plan.

8.6 The Melting Pot: IT management and economic development

In the 'first-level' of our diagnosis with the NIEs, we have discussed the organising, networking, learning and competitiveness, here that will be not necessary because IT is only at the initial stage of development. Therefore, we will limit ourselves to what is happening in SSA in broader terms whenever the scanty literature permits us to do so.

In SSA countries where the dominant situation is the absence of any coherent IT policy at firm level or nation level, it is hardly possible to talk of IT management. In government departments, agencies, or public and private enterprises computers are mostly isolated islands of installations. Based on the limited literature available, we will see how these computers are used and managed.

According to Gahan (1992: 44) there are only few countries in which between 25 and 50 percent of the factories use computers. These countries are Kenya, Botswana, Malawi, Seychelles and Zambia. There is no obvious correlation with country size or with levels of development of the economy as a whole or the manufacturing sector in particular. For instance, Zimbabwe, although it has one of the most elaborate manufacturing sectors, has low usage. The same is true for such large and relatively resource rich countries such as Nigeria, and also for C0te d'Ivoire, which has been making a particular concentration on national IT policy.

According to 'Kenya: national information and Informatics Policy' (1988:192), in Kenya, the first computer was introduced in 1961, but growth was slow until 1975. There were four mainframes in 1965 and 30 in 1975. By 1981, however, there were 127 mainframes and the number has continued to increase steadily. In

1985, it was estimated that there were about 2000 computers in East Africa, 90 percent of which were in Kenya with Uganda and Tanzania sharing the remaining I0 percent. The introduction of minis in the late 1970s and micros after 1980 has contributed in the growth of computer installations. The micros, in particular, have had a significant impact on the public and private sectors due mainly to decreased costs, increased power; portability and user friendliness. They are becoming more popular than the mainframes and minis.

In the SSA countries, the application of IT is mainly restricted to big business organisations, government, parastatals, banking and some educational institutions. These applications include; in Finance: payrolls, invoicing, inventory control; Banking: in-house administrative functions, customer accounts; in Travel & trade: rolling stock logistics railways, airline reservations and ticketing; in Mass media: news agencies (e.9., Routers, sending reports to newspapers), radio, subscriber trunk dialling and international subscriber dialling, including use of phone cards; in Tele-referencing; World Net, which has occasionally been transmitted in some countries T.V.; in Education' universities, Polytechnics, and a few secondary schools; libraries: mainly those of international organisations using computers for information retrieval; Document Productir.tn - Government and micro-computer use by the university libraries.

A study of minicomputers and medium-size mainframe installations, in some Franco-phone African countries, indicate that in 1989 the overwhelming majority of these were in the services sectors, especially in banking, insurance, transport and communications. Companies clearly identifiable as manufacturers were very few. As against this, there is evidence of the use of computers by larger manufacturing firms. In Benin, Societe benonoise de brasserie is computerised for management purposes. In Cote d'Ivoire, Societe ivoirienne de raffinage, Abidjan, uses computers not only for management but for maintenance planning also. In Niger, SONITEXTIL is computerised for management, In Nigeria it is estimated that more than 50 percent of all industry is using computers for accounting, either in-house or using external services ("Computers for industrial management in Africa: the case of Nigeria", PPD.I26, I0 July 1989).

It is not difficult to note that the small available computing resources in the SSA countries are under-utilised. It has been remarked in Mauritius, which is relatively advanced in the application of computers, that much of the existing computer installations are under-utilised (Bunjun, 1986). This is believed to be the case in Nigeria also, especially in the public sector (Akinlade, 1989). This is not, in fact, confined to computing resources only. Capacity or machine utilisation in Africa is in general about 30 percent. But for computers it can nevertheless be in certain cases remarkably high. For example, in Gabon the installations at Air Gabon, Comilog and Comuf function perfectly in extreme conditions (Afrique industrie, No 390, 20 April 1988). But there are many instances where computers are mainly used for word processing purposes only and the utilisation rate may go as down as 10 percent. This seems the case also in Eritrea. This will be discussed in later chapters.

Computer maintenance is another critical factor in SSA countries. There are a number of physical problems that can interfere with the well being of a computer such as: temperature, dust, humidity and irregular electricity supply. The public power supply is, however, the most commonly cited problem followed by dust, while temperature and humidity are minor problems (Gahan, 1992). The telecommunications infrastructure, on the other hand, can affect the computer networks in a country and create problems. Given the poor telecommunications infrastructure in SSA one expects it to be the most problematic area. But up to now it is perceived less problematic than power supply. The reason for this may be that the typical use of computers in African countries does not call for as sophisticated a telecommunication system, with networking and the linking of computers being relatively little known. On the other hand, the availability of a public telecommunications body to supply dedicated data links to computer users would mean that more reliance would have to be placed upon the public telephone network for data transmission, should this be necessary. Now that internet connectivity in SSA is at the forefront, the problematic character of unreliable and limited telecommunication infrastructure will be recognised for what it is poor and unreliable services with vast parts of the countries not yet connected.

The repairs and maintenance issue is likely to be the most intractable of those facing the computer manager in a developing country. In view of the widespread shortage of spare parts and the lack of technical skills, there is certainly a high degree of down time due to unprepared faults. In Nigeria, it has been noted that in extreme cases systems can be out of action for months or even years for such reasons (Akinlade, 1989). The problem of maintenance can sometimes be exacerbated by a proliferation of brands of computers. This may make the problem of a supply of spare parts more difficult and it may make the task of fault diagnosis and repairs more difficult also. The problem of proliferation has been noted in Kenya, where the tying of donated computers to a particular brand is also negatively perceived (Scott, 1989). Government policy formulation in C6te d'Ivoire is directed towards a reduction in the number of foreign suppliers (Computers for industrial management in Africa: the case of C0te d'Ivoire, PPD.154, 21 March 1990).

There has been considerable success recently in developed country markets for what are called fault-tolerant computers. These usually have more than one central processing unit, and indeed most of the internal hardware is duplicated, and this is automatically invoked in the event of failure of the primary hardware. Such computers are widely used in applications such as banking, where continuous connection between the different branches is regarded as absolutely necessary. This could be good news for SSA countries for it could help a lot in alleviating their maintenance problems.

So far, we have discussed about hardware maintenance but there is also the software maintenance. Many software problems are difficult to resolve. It is, in fact, the more subtle errors that remain the longest. Some of them arise through unexpected interactions between different pieces of software, or as a result of incompatibilities between, for instance, the application software and the operating system or between the operating system and hardware, especially peripherals. The latter kind of problems is especially disagreeable. Any computer manager will have stories of a problem for which the different hardware and software suppliers all disclaimed responsibility, each blaming the other as the source of difficulty. In SSA countries this is a difficult problem because the necessary skills are not there in sufficient number. It is a crippling problem that can only be solved by making the required investments in human capital formation.

In SSA countries, it is virtually non-existent the production of computer hardware and software. The supply of adequate support services is also scarce. But something is emerging. May be, one day when enough IT professionals and user market are available, the multinational computer hardware and software companies are attracted by Africa. Then, a real IT industry may slowly emerge in the distant future. At present, personal computers of IBM compatible type are produced in Cameroon. The company INTELAR first launched its Intel 8088-based computer in 1988 and now offers a range of machines including ones based on 80386 processors, video graphics array etc. All the machines are described as being resistant to heat, dust and humidity (Intelar: L'Intelligence artificielle Inc., sales brochure). Cote d'Ivoire is also engaged in the assembly of minicomputers in conjunction with a company from Taiwan province of China (Le courrier, No. 1 13, January-February 1989), and Kenya assembles a personal computer clone, the Neptune.

An example of computer related production may come from Nigeria, where a project to manufacture uninterruptible power sources in Lagos has been identified and is under consideration by United States investors (Snydcr et al., 1990). Trans-Africa Computer Services of Zimbabwe manufactured computers and local area network stations (Computers in Africa, September/October 1988). Also in Zimbabwe, C.F. Tulley Associates and Plessey Zimbabwe have a joint venture to assemble clones (Olivetti and Bulgarian Isotimpex). They were assembling about 600 a year in 1988 (African Business, April 1988).

Many are suggesting that African countries, to make a start in the IT industry, should do so first in software, because the capital equipment costs are lower than in other industries and because there may be domestic market opportunities for software to meet African conditions. For example, a software package specifically for small and medium sized African building contractors has been designed in Gabon (African Business, March 1989). In Mozambique there exist already twenty groups capable of joint serious work in IT, and there is talk of some specialists forming a co-operative (Cumbane, 1989). Business applications for MSDOS machines were written in Zimbabwe by Micropac (Pvt) of Harare and supported in Malawi, Zambia and Zimbabwe already in 1988 (Computers in Africa, September-October I 988).

Computer services also are a major growth area. One survey in Botswana, for instance, gave I0 major companies offering consulting services, supply, repair, assembly and training. One of these companies (Ngami Data Service) offers a specialist program for hunting licences (African Business, June 1988). In 1988 in Cote d'Ivoire there were about 20 computer services companies, and competition was keen. The largest was Cieria (Compagnie ivoirienne d'etsdes et de realisation en informatique et automatisme) which had an annual turnover of about 600 million CFA francs (Afrique industrie, No. 386, 20 February 1988).

Computerising the civil services in Africa would mean a lot to improve the inefficient and bureaucratic systems of African governments. In recent years African Governments are more and more looking to IT to improve the public sector management, hence their institutional capability, and some of their social and environmental problems. The following paragraphs are examples taken from the Bank's lending in information technology (Hanna and Boyson, I 993):

- The Agricultural Services and Institutional Development Project in Rwanda provides support to information systems in a number of public and private organisations, such as the National Directorate of Plant Health and Plant Quality, the Department of Fruits and Vegetables, and the Department of Teas and Herbs. The goal is the establishment of a central support unit with systems analysts and programmers, and a decentralised approach in computing using mostly microcomputers and local area networks.
- In Madagascar, IT is used for ^sector policy and public expenditure analysis, parastatals monitoring, personnel systems, food stock monitoring, livestock production and agricultural research planning.
- The use of IT is targeted for project monitoring and evaluation, development of information systems and services for rural planning, and for local governments and rural institutions. Technologies such as micro computing, facsimile and electronic networks are being used in Morocco and Kenya for this purpose.
- The Bank has funded several projects that include information management systems for planning and monitoring use of land, water and other natural resources, and for integrating environmental considerations into economic policies. Algeria, Tunisia, Madagascar and Kenya are using geographic information systems and other new technologies and approaches to gather and process data on natural resources as well as geo-based socio-economic spatial data, and to evaluate the environmental impact of public policies.

- In the Republic of Guinea, the Bank has financed a project to help the government establish a system for managing forestry and fishery resources. The project IT to manage hundreds of thousands of hectare of forest, register land rights and plan and research offshore fisheries management. A project in Chad is using microcomputers and satellite date, and training local scientists to collect and analyse information to formulate techniques for range land conservation and crop-livestock integration. A forestry development project in Tunisia includes communication equipment, forestry inventory based on satellite imagery, and information systems for research, monitoring and planning.
- It is being applied to energy and transport planning, policy analysis and pricing, regional planning, and railway, port, airline and utility management. For example, the Second Power Project In Zimbabwe, in an effort to make power more reliable and available at the lowest possible cost, is using computers extensively to determine which facilities to rehabilitate and upgrade, and to extend the distribution and transmission networks. A project in Nigeria aims at improving the performance of key transport parastatals. Computer systems are being used in the parastatals to improve internal financial controls, accounting and management information systems, define financial targets, and carry out revenue/cost studies.
- It is being used for planning and research, analysing manpower needs, MIS for all levels of the educational system, curriculum planning, school location and capacity monitoring, and computer assisted instruction. Kenya is using computerised information systems to process and analyse education and financial data and to reform the examination system, making it more efficient and even designing the examination itself.

The Bank IT leading shows that African countries are increasingly looking for IT to solve some of their problems for the projects always have an IT component, But there seems to be a misconception about what IT can do and not do. Automating activities using IT by itself is not a solution. For example, it is not enough to introduce computers to improve debt reporting when the ultimate objective is to improve the capacity to analyse debt problems. Equipment and figures by themselves do not create people trained to use them. As Strassman writes, "A bad strategic situation cannot be corrected by automating it (Gold, 1988; Miller and Doyle, 1987; Heitzman, 1990; Symons and Walsham, 1988; Robey and Rodrigucz-Diaz, 1989; Kaul, Patel, and Shams, 1987; Strassman, 1985).

In general, computerisation in Africa has led to improvements in institutional performance and productivity by inducing local capacity building in policy analysis, monitoring, and evaluation, investment planning and budgeting, fiscal control and accounting, and resource mobilisation. Computerisation has also facilitated marked improvements in public investment programs by supporting efficient systems for dealing with debt and trade management, and industrial promotion. Agricultural and crop management, as well as railways, airlines and port management, have, in turn, benefited from IT use (Moussa and Schware, 1992).

The improvement in performance, however, has not been uniform. In fact, in a large number of projects reviewed, weak project management, unresponsive administration and procurement, inadequate design work, and insufficient training have limited real productivity gains. Moussa and Schware identify five "core" factors that act as constraints on the diffusion and success of IT projects in Africa: institutional weaknesses; human resources; funding problems; the local environment; and technology and information changes. To some degree, all these factors are overlapping. Insufficient planning, for example - a "symptom" of institutional weakness - can result in a shortage of qualified personnel or an underestimation of project costs. similarly, virtually all the symptoms shown (see Table 8.1) can lead to delays in implementation, or to unfinished projects. They have, however, created these five categories because, individually, each focuses on a group of problems that are closely related. It is noteworthy, too, that these factors are not unique to Africa or, for that matter, to the developing world. Institutional and personnel problems, for example, may be found throughout developed countries. The most problematic area - technical specifications of hardware/software requirements - is also a major issue for developed nations. In the African projects, however, the incidence of such problems was alarmingly high. In the category of institutional weaknesses, for instance, they found that well over one-fourth of the projects had one or more serious planning or design problems. In 2l of the 76 projects, the computerisation plan was not sufficiently relevant to organisational objectives. In 22 cases, the objectives of the computerisation were unclear, and in 15 cases, there were serious concerns about the project's feasibility.

While some of these factors are unique to Africa and the rest of the developing world, many can be also found in industrialised countries. The difference is that developing nations have less capacity to overcome the constraints. Accordingly, the implementation of IT in Africa demands far more intensive planning than it has heretofore received. Project design must take into account the client's limited absorptive capacity.

Table 8.1: Key problems/constraints to IT implementation in Bank projects in Africa

Core factors	Symptoms	Consequences
1. Institutional weaknesses	insufficient planning lack of management commitment to and responsibility for IT program Unclear objective and priorities Impractical strategies Tendency for "quick fix" Unpredictable absorption capacity	inadequately designed sys Cost over-runs of varying degrees Implementation delays and chaotic development User dissatisfaction Improper sequencing of activities Inappropriate technology Resistance to change
2. Human resources	Shortage of qualified personnel Inadequate compensation of technical staff High turnover of technical and competent managerial staff Insufficient counte.par(s to external consultants lack of professional training programme or career profiles Inadequate uses awareness	Insufficient support Problems in operation High turnover Implementation delays Risk that project may come to a halt Technical know-how not transferred
3. Funding	Underestimated project costs lack of recurring expenditure	Unfinished projects Implementation delays Higher costs for software Development, Training, repairs
4. Local environment	Lack of vendor representation lack of backup equipment, spares Imbalance between private/public sector wags Inappropriate procurement policies Inadequate site preparation	General lack of professional to solve technical problems Implementation problems and delays High staff turnover Inappropriate procurement Equipment problems and implementation delays
5. Technology and information changes	Limited hardware and software availability Inappropriate software	Dependence on individual suppliers Incompatible hard-software technology Data not shared Over-reliance on customized applications Uncontrolled costs

Source: Moussa and Schware(1992), “Informatics in Africa: Lessons from World Bank Experience”, World Development, Vol. 20, No. 12.

The most difficult question in SSA is the question of sustainability. Even the most successfully implemented projects need be tested against time. The question of sustainability should be incorporated in every future IT project, particularly the funding and maintenance aspects. There is much that can be done to help ensure the successful adaptation and diffusion of IT in Africa. The SSA countries, in particular, should from the outset give due attention to how best can IT be managed. Making computer hardware and software available is not enough. Nor buying computers because it is fashionable. Therefore, a serious thought must be given of where IT strategically fits within the African context and from there depart to fill all the critical gaps to properly exploit it. One of these critical shortages in Africa is that of IT professionals, as it has now and again explained before.

9

9. Conclusions on SSA Countries

In this chapter, it is concisely assessed why SSA countries have failed to use S&T as a base for their economic development and the main lessons summarised following the same structure of the chapter six for the NIEs.

The policies of African countries during the 1960s and 1970s emphasised protection of African industry but placed little emphasis on efficiency and they have failed. The adjustment policies of the 1980s focused almost exclusively on efficiency, and paid no attention to capability building, thus, they also seem to have failed. The balance between these two extremes is very important.

How do you get the balance? There is not a single best answer, but we could see the experience of Taiwan, South Korea and, in the African context, Mauritius to learn from them. These countries first built up strong human capabilities through heavy investment in education; they protected import-substituting industrialisation for a period (not too prolonged) and once industrial capability was established, they changed their incentive system to favour manufacture of exports based on simple and labour-intensive technologies (like textiles). They did not abandon protection of domestic industry, but provided incentives for efficiency through domestic competition and government pressures on firms, including pressures to enter export markets and face competition from international markets after a predetermined number of years. Allocation efficiency was promoted through realistic exchange rates, fairly low protection levels and relatively low wage rates. South Korea particularly relied on vertical pressures, while Taiwan and Mauritius more on horizontal pressure (Ranis, 1990; Amsden, 1989; Wade, 1984).

Besides human resource development, Africa needs foremost policies for efficient industrialisation. Learning from those that have done it is possible. They have to be able to develop their own industries and run them efficiently without over depending on others to do the job for themselves, which is very costly anyway, therefore, unsustainable. Despite some successes, the overall assessment of past patterns of industrialisation from the perspective of capacity utilisation, industrial linkages, growth in productivity, reduced dependence on foreign management and technology and experts, is negative in Africa (Lall, 1992, in Stewart, Lall, and Wangwe eds. 1992, 22).

It is well known that 'skilled manpower' is central to technological capability, thus, to effective industrialisation. African economies are potentially rich in human resources, yet people are relatively neglected, badly educated and in poor health with their capacities frequently underused. The consequence is low labour productivity and lack of competitiveness compared with countries where human resources are more fully developed and better used. This is so despite the fact that low wages should make African economies very competitive (Helleiner, 1992). Where human capabilities have developed, unattractive conditions of work have frequently led to massive brain drain.

9.1 S&T and economic policies integration

It is difficult to see clearly in the case of SSA countries the interplay of S&T and the economic policies. To appreciate it better a broader definition of S&T can help. This is not a S&T environment where a large number of R&D institutions, whether linked to universities of industries, and industrial complexes interact in the process of innovating and diffusing of new technologies like it is the case in the industrialised countries. In SSA countries it is only possible to talk of technology transfer, the efficient utilisation of technology, the development of technical skills, the diffusion and learning of new techniques. Of course, the activities of higher learning institutions like universities, polytechnics and technical schools is an integral part of the process as institutions entrusted with the responsibility of generating skills and introducing new techniques and technologies. But the industrial research is virtually unknown in SSA countries for the simple fact that they are at the initial stages of industrialisation process.

Since every serious technological industrial development is based and preceded by technical skill development, it is important to ask whether the skill generating institutions are integrated to the needs of the emerging industries in the SSA countries. This was not the case. SSA countries have created educational and training institutes inherited from their colonial masters or built directly copying the structure of those in the advanced countries. Universities were established on the basis of 'publish or perish' principles one finds in the advanced countries. This have led African academicians to look for the outside world for models and recognition (international journal publications) regardless of whether the subject of their research and findings are relevant or not to the economic development of their country. The paradox in fact lies here. A poor country makes investment in research that should benefit first itself. But the picture above is the opposite. Indirectly amounts for the poor country financing the advanced countries' research for they only have capacity to exploit scientific result at the scientific frontier. Their research should have focused on best technology transfer and diffusion to strengthen the country's industrial development. The same could be said of the few R&D institutes. These should have helped to support the weak emerging industry at home. But it was not the case.

Similarly, matching the skills produced by the higher learning institutes to that of the demand in the industry is important. But in this respect also there is a clear failure. The shortage of highly skilled manpower in SSA countries is still in place. What is worse is that even what is available is of a poor quality, given the poor resources with which the institutions are supposed to work. Curriculum is not revised to keep it in line with the needs of the industry, particularly that of the technical schools. The skill generating institutes and the industry are so far apart that relevance of curriculum is a subject mostly given a lip service only. Industrial technologists do not participate in the design of curriculum to make it really of some value to the industry. Usually industry chooses in-house training to create the skills needed. It is by far the most relevant kind of technical skill generating that is taking place in the SSA countries. It needs to be recognised and given due support.

Even the light industry requires primary education to support the trainability of simple techniques to their labour force. But this basic education has remained so low for so long in the SSA countries. In 1995 the net enrolment ratio as percent of the relevant age group at the primary level was above 90 percent for only four countries of the SSA countries.

In general it is possible to conclude that the higher skill producing institutes in the SSA countries have not moved in pace with the industrial needs of their countries. Their activity was dominated mainly by teaching and they have failed to give support to industry in industrial consulting services, in industrial technology research, and special skills training. The existing total separation of industry from higher learning institutions is recognised as unproductive and wasteful structure but concrete action to change it have not come yet. Of course, there are some isolated attempts by isolated institutes but are not sufficient to change the landscape.

From the fragmented literature available on industrial policies in the SSA countries, it is clear that these countries lacked a coherent industrial strategy linked to the rest of the economy. The macroeconomic policies in SSA countries were swinging from agriculture bias towards industry bias causing damage to one sector or the other. All sectors of the economy are important but depending on circumstances some sectors are given priority over the others. But there is always a minimum level of activity in each sector for the whole economy to be viable. To implement economic policies skills, tools, equipment, machinery, and know how is required, which in simpler term is called technology. It is this technology with which a given economic policy is to be pursued that was not made clear. Those responsible in the different economic sectors at the implementing end finds it difficult to make the technological choices and manage them efficiently, assuming they make the right choices. Macroeconomic policy-makers assume this particular spot to be frictionless if the S&T aspect of the policies are not studied and guidance given. This assumption has proved to be very costly to SSA countries. It is not very difficult to see that many policy makers consider importing the technology (equated to buying the machinery), installing it, giving .some basic training to operate it is all there is in mastering technology. This is not true. Mastering technology is a very complex issue that cannot be left to chance. You need a host of institutions to support it. S&T policies should help build, manage and improve institutional framework for the best way of organising and developing scientific and technological activities capable of supporting all kind of industrial sectors. This is why macroeconomic policies or national economic development plans should incorporate the S&T required to making it a success. This integrated approach is what is missing in SSA countries.

The melting process could not work properly because the main ingredients are missing. These are factors such as a clear vision of what technology for what specific objective of economic development; institutional support to small private firms and entrepreneurs during their learning period, in terms of finance, technical and marketing support; efficient large and medium sized indigenous private sector; interest by foreign investors in SSA countries; and development-related debt to finance state-sponsored industrialisation in area where the private-sector fails to invest, assuming that public sector is professionally managed and works by the rules of the market.

The de-industrialisation process observed, particularly in 1980s, may continue in absence of significant money flowing towards the SSA countries than is actually the case at present. Many of these countries are desperately trying to meet their huge debt service charge. Many are continuously asking for debt payment rescheduling and still unable to meet them. The exit from this impasse is not clear yet. Debt cancellation would greatly help. But even that will not be enough. All types of conflicts going on should stop and the political stability restored first. The rule of jungle should be replaced by the rule of law. Only then the confidence of foreign investors can be restored and the above mentioned missing things can be put in place and reverse the grim picture of the present times.

9.2 Priority given to IT

In SSA countries, the very awareness of IT importance and pervasive character is very low let alone considering IT for priority in their limited S&T activities. Recently, the AISI came up with a vision, strategies and objectives that the African countries should follow to make the most of IT in the coming decades, so that Africa does not remain marginalised. This is a great contribution to improve the awareness of the SSA governments but by itself cannot generate anything useful and the actual push should come from each country.

Computers have been coming to SSA for a number of years now, but more needs to be done to really feel the difference they can make to a society in general and to the economy in particular. Appropriate national IT policies and plans well integrated into the very economic and social fabric is what is needed. That was not the case for S&T in general and to expect it for IT would be simply farfetched. This is because S&T have never been truly addressed in SSA countries and industrialisation has never benefited the real support it needed. Radical change in thinking and attitude towards S&T in general is required. In particular, being this the era of microelectronics revolution. IT need be given a more serious attention than letting computers come in to the country.

A computer is not a magic tool that the mere presence of it makes wonders. If not properly used can be the most expensive gadget added to the already long list of underutilised machinery and equipment in the SSA countries. This becomes automatically an unsustainable game. Therefore, this kind of trend need be reversed and IT should be made to increase returns by reducing costs. The first to benefit could be the large, corrupt and inefficient government administrations in SSA countries. The potential is there to increase the quality of social services as well as that of industry in general. Particularly the efficiency and reliability of transport and communication services, the financial services and tourist services could improve tremendously and could be linked to the global economy with ease. Of course, the international competitiveness of such industries could also improve.

Even though help is necessary to build S&T in SSA countries, it should not be based on it and left to the whims of donor countries or aid agencies. SSA countries have never left their defence needs to outside help alone. Why not do the same for S&T for the sake of a sound economic and social development?

9.3 Institutional capability

Institutions are the basic fabric of a society. 'They shape the rules of the game in society and are the humanly devised constraints that shape human interaction, structures the incentives in human exchange (political, social or economic)'(North, 1990). These institutions emerge cither spontaneously over time (customs and tradition) through simple interaction without premeditation, or they can be the result of a conscious plan. In economic activities, the institutions that are the result of 'free interaction' are known as the markets. Government institutions, on the other hand, are established to consciously manage the life of a society in a way that serves best the group of people that it represents.

Coming to SSA countries, both the governments and the private firms are active in the economy. But many governments have shown the tendency to control and direct the economy in various ways. This is in a situation where the markets are small and yet not fully grown, like what one seen in the developed countries with exceptions in the urban areas, particularly that of the capital cities. Much of the structure of the government institutions and markets is based on the colonial legacy. Dissect between the urban concentrations and the rural traditional African life is very clear and conflict of interest has become inevitable. For example, the government proceeding with its projects of exploiting the natural resources of the country such as in timber and mining industry as well as the wild life preservation and the making of national parks, inevitably enters in direct clash with the traditional and rural society's way of life. These communities live on hunting, pastoral life and subsistence rural fanning. Their very livelihood depends on the forests, pasture lands and land in general. The idea is of destroying entire communities' life to build a new and better life based on industrialisation with all the new set of value system of a consumerist and materialistic society. After having done that, the expected better life is not there. The only thing one could say, then, is that the people would have been better off in their old peaceful way of life with less material prosperity but in harmony with nature and a stable community support system not available under the new situation. But the next question is if that could be possible at all.

Multinationals and their drive for the global economy is pushing everybody in the world to an endless drive towards more production, consumption for the sake of wealth generation for the minority rich people. The old 'gold rush' mentality is still here with us driving these new colonisers for more new land, markets and new gold. But there is a limit to earth's natural resources and the national and international institutions should change the rules of the game. Both government institutions and the market forces should work hand in hand to bring the desired change. Market forces alone will do never that, as the past has amply demonstrated.

SSA countries, therefore, should have the courage to look into the matter and understand the need to balance the urban and rural development. S&T is the best tool to natural resource conservation and sustainable exploitation. For example, wild life conservation in national parks and tourism industry can be linked so that the growth of both is attained simultaneously. But the people and the communities in the area have to be the main beneficiaries and should, therefore, participate in the projects from planning to implementation.

In SSA countries there is a very small number of institutes engaged in S&T activities and its diffusion. The universities and other institutions of higher learning are mainly engaged in the production of highly skilled manpower. Even this manpower is, at times, inadequately prepared {.o implement technology plans critical to the country's industrial development. Add to this the missing link between policy makers, S&T institutions and industry. This is why there still exists lack of conscious effort and support to study, upgrade and adapt indigenous techniques to a level of mass production in industry.

Finally, the institutional capability to enable the SSA countries build up information and communications infrastructure is very weak. IT, as the basis for such an infrastructure, is only beginning to be recognised and the international agencies are trying to assist the SSA countries to get connected to the global economy and the international community through the Internet. But more need to be done and soon.

9.4 Human capital formation

First of all, there is not enough information to tell exactly the extent of human capital stock in the SSA countries. Based on what is available, the picture we make is very poor indeed. There is extreme shortage of skilled manpower virtually in every field. At the same time, the poor industrialisation level makes it very difficult to keep the skilled available manpower and brain drain problem is acute and common to all.

The major employer in the economy is the subsistence rural economy followed by the government defence force, civil services, and public enterprises. African scientists and engineers don't have many opportunities to work outside the few higher learning and research institutes and ministries. Even the universities are mainly geared towards teaching, and research is only a minor activity.

Technical training does not adequately meet the demand both in terms of quantity and quality. The curriculum in schools has only very limited technical subjects not to say that technology is not integrated into the school system in general. This shows that SSA countries need to make a significant investment in technical skill development if at all any serious industrialisation process is to succeed even at the level of light-industry development.

IT skills in SSA countries has an even worse image of what has been said of technical skills in general. The basic computer skills were first acquired through in-house training or sending staff abroad for training. Education ministries were usually very slow to react to the appearance of computers. Some private schools have jumped to exploit the opportunity and have made significant contribution in giving the basic computer operation skills. But quality is at times questionable. There are also a few universities that have introduced diploma and degree programmes in computer science and information systems, but it is a drop in the ocean.

The most critical IT skills are still missing. There are very few African IT professionals in SSA countries that can make systems analysis and design and carry it all along to the implementation and make it operational system. Today to exploit the full potential of IT you need experienced teams of professionals such as analysts, designers, network experts, database administrators, communications expert, and hardware and software engineers and maintenance engineers. This important link is missing in SSA countries and using foreign experts is unsustainable. Action need be taken immediately to reverse the situation.

9.5 The Melting Pot: technology management and economic development

In SSA countries before asking what is the result of the 'melting pot', one needs to ask whether the ingredients were in the 'pot' in the first place. To make the point, let us go back to the existing situation.

The main players in industry are the government through the public enterprises, the multinationals in the extractive industries, and the small private enterprises. The question now is whether these three main players had been guided by macroeconomic policies that would reinforce a mutually supportive industrial structure to enable a sustainable economic development for the country. The other is whether this same macroeconomic policy envisaged the gradual build up of an industrial technology. The answer to both is negative.

Policies in SSA countries were changing frequently either because of political instability or to suit the political and economic interest of the ruling elite and enrich themselves and their prot6g6s through rent seeking behaviour, Long-term technological development to increase their countries international competitiveness was only remote to the whole process of policymaking and industrial management or at best paper work only. This can be said of all SSA countries, may be, with very few exceptions.

9.6 Lessons learned

SSA countries need political stability and a transparent political system first and foremost. The first innovation, therefore, has to be found in the political arena. Ethnicity is not the problem for political instability. It is the fight for political power and the economic control of the leading elite using ethnicity as a means to mobilise supporters by promising gains for one’s own social group. Therefore, equity, justice and participation of all sides could solve the problem.

The next move from there would be a good macroeconomic policy based on the consensus of all parts. This macroeconomic policy should have embedded in itself the S&T policies and projects to make the development of the necessary industrial technology for a sustainable economic development in the country possible.

IT is a very useful and pervasive technology to be left alone to chance by the SSA countries. It can contribute to improve the transparency and efficiency of the government administration. It can also increase reliability and efficiency of industry in general by bringing it closer to the global economy and markets. In particular transport and communication, trade, financial services and tourism industry could immediately benefit from it.

Now we will try to summarise the lessons in terms of sustainability, flexibility, quality, priority and result as we have done in the case of NIEs.

I. Sustainability

- In SSA countries, the 'development-related debt' or industrialisation based on easily obtained debt proved to be unsustainable. The industrial plants were not both carefully designed and implemented or the revenues generated were siphoned by corrupt government officials to their personal accounts in foreign banks. Therefore, SSA countries must strive for better development-related debt management and corruption-free public servants.
- The generation of skills was not in line with the demand made by industry or at least was not of the right quality. As a result the lower productivity of labour and or the lower quality of industrial products were uncompetitive even in local markets, therefore, unsustainable. Therefore, skill development should be related to the industrial demand and better human resource management to improve the labour productivity and reduce brain drain of the region.
- The S&T bodies were unable to direct the technological development because they were in a weaker position to influence industrial decision-making or had not the required budget to function properly. This should be reversed.
- Technical and engineering skills were not given adequate attention and as a result S&T for industrial development could not take off. Technical and engineering education should be strengthened.
- Heavy debt burden had a detrimental effect to industrialisation because international financial institutions asked for 'structural adjustments' that in turn led to less money for education, technical training and industrial technological development support. Structural adjustment should be taken with caution and on a case by case basis without disrupting the investment on education and industrial technology.

2. Flexibility and transferability

S&T is a fast changing environment. But scientific information flow to the SSA countries is very slow and small. Thus, they are less sensitive to important changes in technological trends.

- Universities are the major S&T institutions in SSA countries. But starved of money, they are increasingly loosing the best people and their development in the best of the cases have grown very slowly or remained stagnant. [n some cases their quality deteriorated. Definitely, they are not the centres of change. Therefore, they should play a major role as agents of S&T change.
- The diffusion of best practice and promising technologies and techniques are difficult and take a lot of time. At times, they don't even diffuse because hardly institutional support exists to help the small and medium-sized private firms to try it and absorb it. Diffusion of industrial technology should be institutionally supported through the creation of smaller but flexible institutions that evolve with the demand of their services.
- Political appointees are heading most of the SSA countries' public enterprises. They are more concerned to please their bosses than managing professionally. Thus, the leading by example

required by top management at the critical time of technology transfer and learning is very difficult. Public enterprises should be professionally managed to rever.se this trend.

3. Quality

SSA countries are far behind in building the culture and mentality required for quality industrial activities.

- They lack experienced and skilled manpower in sufficient quantity, but more so in terms of quality.
- The quality of public service institutions is very poor. In S&T activities, in particular, the few good institutes are islands in a landscape where the majority is of lower standard.
- Networking among different institutions is very poor. Particularly that of regional institutional networks is almost non-existent or ineffective.
- The multinationals present in SSA countries are mainly engaged in the extractive industries. They did not have any spin-off effect on the other industries. At times, they have contributed to the state plundering by co-operating in fund transfer to personal accounts of corrupt officials (example in Zaire, Nigeria, Angola etc.).

Therefore, SSA countries should understand that quality is the key to international competitiveness. This can come only if quality consciousness is made of the people's culture. The governments should use their purchasing power to raise quality awareness among local suppliers. For that matter, the wide practice of buying abroad for quality reasons has a detrimental effect to the quality of industrial products at home. This tool should be used effectively to build the culture of quality in their respective countries. In fact, they should start by making high quality of service standards from the civil services first.

4. Priority

- There seem to be no technological priority in SSA countries.
- IT is not given priority nor SSA countries are investing enough to prepare the groundwork for the exploitation of IT as an infrastructure. The danger of being marginalised in the global markets is ever increasing.

It is time for SSA countries to make science and technology assessments and make choices relevant to support their country specific industrial development needs. IT has become an infrastructure, without which is impossible to get connected to the global economy, and as such the SSA countries should take more seriously than has been the case in the past.

5. Result

- In all respects, SSA countries have lagged behind. Poor institutions, poor skilled manpower, and inefficient and corrupt government administrations have filled the African landscape.
- SSA countries industries do not count in the global economy and as such it is not possible to talk in terms of international competitiveness outside the primary products supply.

The least developed countries must get the international community support to educate and particularly to train their people in technical skills. There is no question about those burdened by the debt, they should be relieved and helped so that they can incest in their people. Only when people are educated can they fully participate in the political and economic life of their countries. Above all, Africans themselves must develop regional cooperation and networks among themselves in order to be able to solve their political, social and economic problems.

So far, SSA has failed to develop the very basic elements of S&T and the small achievement made is not integrated to its socio-economic development. Some African countries, take for example Nigeria, have the natural endowments and a critical mass of highly educated manpower but the political instability is blocking the country from the path of development and catching up with the developed world. Let us hope that the current mess existing in Africa will be remembered in African history for the contributions it will have made for learning from the mistakes being perpetrated in the social, political and economic life of Africans. Africans had enough of it. Hopefully soon, they will take control of their lifc. But at the same time, the international community should stop in particular those who fuel instability by selling arms in the region. If not, it will backfire. In a world reduced to a big village, tanks to communications and transport technologies, protracted instability will fuel international terrorism. Our globe will be less attractive to live in. The preaching of democracy made to Africans, alone, cannot change things. It is possible to use election systems to perpetrate subtle dictatorship or control of power by few elite (no problem if the interest of the West can be maintained through these elite) while the masses have no real voice. More than anything else stability pays economic dividends. Therefore, a real partnership is required from all sides, the advanced countries and the developing ones, to make the world a better place to live by using science and technology at the service of humanity.

PART III

Science and Technology in Eritrea

This is about a very young country. Young age is the time of energy and dreams.
If taken seriously and guided properly that energy can turn dreams into reality.
Eritrea can use its energy to master S&T in the fight
against poverty, diseases and illiteracy.

Part III deals with the case of Eritrea. The study question is the same to what we have tried to answer in Part I and II. What is the state of S&T policy and management in Eritrea? What is the state of its IT? IT starts with S&T in general. IT tries to assess the implicit and explicit policies with regard to the promotion of S&T in the country form the point of policy, human resource development, and institutional support and the integration of it to the economic development plan. This is followed by the assessment of the IT diffusion in the country including policies adopted and the implementation of them. The study was meant to have a complete integrated view of the present situation in the country including the lessons learned so far.

In the chapter on the 'Future of Information Technology in Eritrea', an attempt has been made to give the general trend of S&T in the world. This is followed by what Eritrea could do to bridge the gap using policy instruments to guide the development of its human capital formation, its institutional capacity and in particular the use of IT as an infrastructure on which to build the county's economic development in the future. Finally, the research concludes by giving some major recommendations.

10

10. S&T in Eritrea

10.1. Introduction

In this chapter we will focus on S&T in general because in the next we will see IT in depth. It will immediately be apparent that Eritrea is a beginner and faces a dearth of institutional capability and lack of highly skilled manpower in every aspect but more so in S&T. Policy analysis in the country is at its inception. The grand vision presented in the Macro Policy of 1994 has yet to be supplemented by detailed S&T policies that can be the basis for the true development of industrial technology.

Eritrea is the newest country in Africa. It is beginning to build its economy from the ashes of a destructive 3O-year war of liberation from Ethiopian rule. It has witnessed a rapid deindustrialisation process during 1975-1991 period. The industrial technology base left by the Italian period has completely died. This shows how wars and civil conflicts in Africa are claiming heavy losses on the very socio-economic fabric of their societies. This is one of the major factors why science and technology development and the resulting industrialisation in Africa have been very disappointing. On the other hand, the industrial plans and policies of Africans ale inadequate and so is the institutional infrastructure needed for industrialisation. The results are limited financial resources, under-utilisation of installed industrial capacities, inadequate industrial skills, poor ability to negotiate for technology, and deficient industrial and technological information.

In this chapter we will explore the situation of science and technology in Eritrea. We will start from the historical and present state of industrialisation of the country. The historical and current industrial development of the country will be used as the basis of the analyses to be made later with regard to S&T policies and management, human resource development, and institutional capability development so far achieved in the country.

10.2 Environmental context

Eritrea, as a modern country with the present boundaries, was established only a little bit more than a hundred years ago when the Italians first colonised it in 1890. In the 1940s and 50s, by the standards of other African colonies of the period, industry in Eritrea was highly developed. But with the change in the world order after the World War II, Eritrea enters a new chapter in its history, which led it to a very destructive and long, 30 years, war of liberation. The progress Eritrea had made has been undone and its industries and the highly skilled and extensive working class were lost.

This tiny country's interest was sacrificed to propitiate the strategic interest of the super powers in their fight to maintain and expand the zone of their influence in a world divided into two parts: the capitalist and the socialist camps. The Americans and the British felt more secure if Eritrea were annexed to the Ethiopian monarchy. This political decision made outside this country cost beyond the proportion of its small size. Now it is one of the least developed countries in the world where the struggle of catching up is very difficult. Industrial technology is at its lowest. The existing highly skilled manpower is insignificant and the institutional capabilities are at the lowest level. But fortunately, there is a sense of purpose and determination on the part of the government and people that anything is possible for those who work hard as has been the case in the war of liberation. This culture of 'we can do it on our own' has matured during the years of struggle and is infusing hope and self confidence, which are very important for getting results.

At present Eritrea has a population of 3.8 million and the GNP per capita of US$ 210. Its GNP is US$801 millions with one of the lowest total debt outstanding and disbursed of US$76 millions in 1997 (World Bank World Development Report 1998/99). The economy has achieved an average annual growth rate of about 6 percent in the five years from 1993-97(National Economic Policy Framework and Program for 1998-2000, p.5). In 1995 agriculture contributed 11.2 percent, industry 22.7, distribution services 39.3, and other services 26.8 of the GDP. In 1996 agriculture contributed 9.8 percent, industry 27.4, distribution services 40.1, and other services 22.7 of GDP (IMF 1997, Eritrea: Selected Issues, p.4.). Inflation averaged around 6.5 percent in the last five years from 1993 to 1997 (National Economic Policy Framework and Program for 1998-2000).

Full background information of Eritrea's industrial development in given below. After that, we will directly go to the analysis of explicit and implicit S&T policies that have most impact on the economic development of the country.

History of the Industrial Technology in Eritrea

During the fifty years of Italian colonial rule, the Eritrean economy was substantially transformed. This transformation took place in the form of large-scale urbanisation, transportation infrastructures and light industrialisation, and the formation of a pool of skilled manpower. Historians attribute this rapid change particularly to the Italian invasion of Ethiopia in 1935. Eritrea was used as the base for the commercial and political penetration of Ethiopia which was considered ideal for the demographic colonisation as well as a classical colonial strategy of developing sources of raw material and markets for metropolitan industry of Italy (Kellion, 1996, p 97 /98).

It is not difficult to see the transfer of technology that was occurring in every major project undertaken before preparations began for the invasion of Ethiopia. The most important projects are:

- the construction of a medium-gauge rail line from Massawa to beyond Akordat, via Asmara and Keren:
- the construction of a network of primary and secondary roads, particularly in the central highlands;
- the reconstruction and expansion of the port of Massawa after a devastating
- earthquake in 1921;
- the development of large -scale irrigated cotton production around Tessenei modelled on the Gezira project in the Sudan;
- the development of citrus and sisal plantations on the eastern escarpment and the Keren area;
- the expansion of salt production at Massawa and Assab, and the development of potash mining in the Danakil depression (see Yemane Mesghenna, 1988; Araia Tseggai, 1981; Tom Kellion, 1996).

It was a decade of intensive economic development, from mid-1930s to mid 1940s that transformed Eritrea's society and economy from one that was overwhelmingly rural and traditionally based to one with a significant urban and industrial component. This transformation occurred in two stages under two different political regimes. But both stages were driven by the same primary forces of massive state expenditure on war- related projects and a massive influx of Italian nationals. The first stage, 1934-40, involved the Italian invasion and occupation of Ethiopia, which transformed Eritrea into transportation centre for the short lived

Italian East African empire and increased the Italian population of the colony from about 600 to 100,000 as given in Tablel0.1 below (G. Cerbella, 1959).

Table 10.1: Italian population in Eritrea

Year	Population
1892	585
1894	963
1902	20t4
1905	3942
1937-1940	50.000
1941-1842	I 00,000
1943-1845	60,000
1946-1952	30,000
1952-1960	10 000

Table 10.2: Industrial activity in Eritrea in 1938 (excluding mining, fishing, catering, and artisan works)

Type of enterprise	Number of firms
Construction	383
Construction materials	241
Transport	846
Mechanical works	227
Beer, ice, and malt	25
Flour milling, pasta and bakeries	269
Textile	3
Wood and furniture	96
Printing press	13
Chemicals	18
Tanning	7
Electrical	I9
Entertainment	51
Total number of firms	**2198**

Source: Compiled from G Fiore, 1950

The second stage, 1941-45, involved the British conquest of Eritrea and the rapid development of a light industrial economy subsidised by Anglo-American wartime policies, but built and manned in large part by the 60,000 Italians who remained in the colony. The sustained war-boom brought on the Eritreans a tremendous social transformation (Table 10.2). Massawa port, by 1935, boasted the most extensive harbour facilities between Alexandria and Cape Town (Ceylon, 1936). In 1937 Assab became the only entr6pot for Italian East Africa. Asmara and Dekemhare became the centres of a regional road transport industry that employed 100,000 men. By the mid- 1940's roughly 20% of Eritreans lived in urban areas (Keilion, op,cit.). In 1947 the industry was employing 33,699 workers of which only 5,675 were Italians and all the remaining were Eritreans (G.Fiore, 1950). It was also diversified but always within the light industry (Table 10.3). It was a tremendous transformation indeed.

Even after the Italians lost Eritrea in 1941. The economic boom continued because the British Military Administration retained the Italians to continue to work in the civil services and encouraged Italian entrepreneurs to develop import-substitution industries and agricultural estates to serve their war time needs. The Eritrean industries grew particularly in food processing, chemical, glass and shoe manufacturing, as well as increased agricultural production, to satisfy local and regional demand through wartime marketing parastatal, the U.K.C.C. (ibid. p. 103).

Table 10.3: Industrial activities in Eritrea, 1947

Type of Enterprise	Number of Firms
Flour milling	94
Manufacturing of pasta	14
Bakeries	64
Milk and milk products	35
Oil /fats production	10
Alcoholic beverages including aceto (vinegar)	42
Canned food	11
Pastry	10
Business farms	29
Drug manufacturing	12
Soap factories	20
Perfume and cosmetics	6
Glass, ceramics, and paper	21
Doll manufacturing	4
Timber products	29
Mining	43
Tannery	22
Textile and clothing	21
Construction	33
Chemicals	29
Electricity production	26
Metal works and auto garages (mechanici)	119
Cinemas (total capacity of 16,654)	20
	38

Source: Compiled from A. Infante (Dott.), 1947

At this particular time, in 1946, the British opportunism was very apparent in their very act of dismantling, removing and selling-off much of the infrastructure built during the Fascist boom, including Massawa's port facilities, cement factory, aerial cableway and Gura airfield (Pankhurst, 1952). This marked the end of the war boom and a new era of uncertainty appeared on the horizon. But as a leftover of the Italian East African colony's legacy, the Ethiopian market for Eritrean light industries and transport services remained intact. It even grew after Eritrea's federation with Ethiopia.

Italian capitalists and entrepreneurs dominated the Eritrean economy from the beginning up to 1974, the beginning of Ethiopian Socialist Revolution and the intensification of the war of liberation in Eritrea. The exodus of the Italian population started immediately after the World War II and culminated in 1974 with the coming of the Ethiopian socialist revolution. It was already clear that Italian investments were markedly decreasing by the end of the 1950s (see Table 10.4). As the Italians were going away progressively it meant more employment opportunities for Eritreans, but also reduced demand for many local manufactures and services. Nonetheless, an Eritrean urban working class and middle class formed during this period, and it was these classes in particular that created the nationalist movement that was to profoundly alter the Eritrean political economy during the post-war period.

Table 10 4: Business Licenses in Eritrea 1945-1960

Business type	Year						
	1945	1949	1953	1956	1958	1959	1960
Retail	-	1773	1349	1315	1325	1136	341
Wholesale	1117	-	162	161	287	138	169
Import/export	-	301	334	334	327	198	172
Commercial agents	-	-	-	62	60	60	44
industrial	527	977	395	456	627	616	486
Artisan	1221	814	745	968	1009	350	305
Total no. of licenses	2865	3925	2985	3296	3635	2498	1517

Source: G. Cerbella. 1959, p. 168.

The sad part of the story starts in 1962 when Eritrea was officially annexed to Ethiopia, The Eritrean economy enters into a more or less 'permanent recession' (Kellion, op.cit. p. 106). It signals also the beginning of the exodus of many skilled Eritreans migrating to Ethiopia, Sudan, and the Arab world in search of employment. "It was during this period, late 1950s early 1960s, that the Eritrean economy began to rely in some measure on remittances from abroad to maintain living standards. Many of Eritrea's best educated, wealthiest and most skilled people relocated to Addis Ababa, and Asmara was reduced to an economically stagnant provincial city. Thus, despite its industrial infrastructure and skilled workforce, Eritrea - outside Assab - was fast becoming an economic periphery of the Ethiopian Empire" (ibid. p. 107). The Emperor's own effort, backed by large sums of USA capital, concentrated on developing Ethiopia's industrial capacity in the central Shoa provinces at the heart of the Empire. But by 1970 Eritrea still accounted for over a third of the industrial activity of Ethiopia and Eritrea combined (Firebrace and Hofland, op cit. pp.7l-72).

By the time of the Ethiopian socialist revolution, in 1974, investment had ceased, and with the escalation of the war in early 1975 Eritrea was clearly on the brink of another economic phase: that of destruction. The 17 years of full-scale warfare in Eritrea (1915-1991) effectively destroyed the colonial economy. The transport system was completely destroyed. Many towns were completely or partially destroyed and the nationalisation of private property and industry by the Ethiopian revolutionary government (1975) led to the final exodus of Italian industrialists. Massawa was damaged by bombings after its liberation (1989). Other losses are the military related deforestation and the estimated loss of 80,000 cattle, 14,000 camels, 200-300,000 sheep and goats. The human losses, around 185,000 guerrilla fighters and civilians died in the war, over 12,000 fighters permanently disabled; and more than a million people fled their homes (Kellion, op cit. p. 108-10).

The above brief account gives a clear picture of the ups and downs of the Eritrean economy up to 1991. But it is by no means complete because there is also another side to the story. A new political economy was being shaped as the new nation was emerging from the bush and the war of liberation. By the end of 1977 the Eritrean freedom fighters controlled all of Eritrea except Asmara and other two towns (the ports of Massawa and Assab), but were unable to operate most of the factories for lack of raw materials and missing or damaged parts. In spite of the difficulties, the fighters were able to operate the power stations in all towns they occupied, maintain telephone communications and water supplies, and run some smaller factories including the Keren groundnut and incense processing plants (Firebrace and - Holland, op. cit., p 71). The EPLF made maximum use of the period 1977-78 to expand their light industries in the base area, bringing out machinery and raw materials from the towns captured. Thousands of skilled and semiskilled workers joined the EPLF to be employed in the workshops of Sahel province and in operating the newly acquired plants and equipment. Most of the workers joined the front at this time. According to the EPLF estimate, in 1971 alone the number of skilled workers in the EPLF increased threefold; by the end of the year they were producing millions of pounds worth of material and covering 80% of the needs of the front (ibid. p 71).

Since the withdrawal of the fronts to their base areas in mid 1978 the EPLF's industrial sector has continued to expand. A sound technological base was being established. It was based on the concept of self-reliance because it was the cornerstone of the Eritrean revolution. During the visit James Firebrace and Stuart Holland made to Eritrea during the war of liberation in 1985, they witnessed the fact that 'self-reliance' is no empty slogan but an integral part to all the economic activity of the EPLF. At that time, self-reliance was the means for satisfying the EPLF's material needs. Today after liberation, it is seen as a strategy for improving the overall productive capacity of the Eritrean people. The Government of Eritrea does promote trade relations based on mutual advantage and seeks economic assistance free of political strings.

The concept of self-reliance in Eritrea evolved in the long years of war of independence as a result of necessity rather than of pure ideology. The two big superpowers were on the side of Ethiopia and Eritrea had to rely on itself and its own resources and people. It did work. Already in 1982 EPLF stand on self-reliance was mature and clear. "Self-reliance is a necessary precondition for the establishment of an independent and developed economy. The pursuance of a policy of self-reliance is essential for the total independence and liberation of a society. Politically it is the only means to complete freedom. Economically it is likewise the only means given...prevailing international conditions that enable people to develop their economic potential depending on their own material and human resources. Socially, it is an essential liberating process, emphasising as it does working co-operatively and collectively to satisfy your own needs. Dependence breeds subservience and lack of self-confidence. Freedom from dependence enhances a people's independence of thinking, innovativeness, perseverance and pride in work and struggle' (Firebrace and Holland quoting EPLF, Self-Reliance in Economic Field, 1982).

During the war of liberation, every visitor to the base areas of the EPLF commented on the ingenuity of the workers in the EPLF workshops. Not only were spare parts, cooking utensils, teaching materials, aids for the disabled, and hospital equipment put together from the captured debris of war, but EPLF was also constructing many of the machines necessary for producing these items. Firebrace and Holland observed that the most useful materials were the wood from ammunition boxes, shell and bomb casings, springs and sheet metal from destroyed vehicles. The process was almost literally from shells to ploughshares. Every available material was put to good use or recycled. The containers, the watches even the black plastic sandals which all EPLF fighters wear were locally produced and then recycled (ibid. p.74).

Let us look a litter deeper at the work done during the war times. It is clear that it is all learning and straggling to survive by your own means, it was learning under stress and continuous crisis. Perhaps one of the greatest signs of the maturity of self-reliance could be seen in the big hospital, drug manufacturing, and the various workshops and garages the EPLF were able to establish to meet all their needs. The technology in the workshops was sophisticated and included a number of lathes, drills, saws, a truck brake tester and electrical testing equipment. One of the engineers at the She'eb estimated that they could make 60% of the vehicle spare parts in their own workshops. Many of the machines used in the workshop were made by themselves. This included a power saw, a metal planing machine, a hydraulic press, metal grinders, an angular metal-bending machine, a tabular metal-bending machine and a forge. They were constructed from a variety of materials including broken truck springs, chassis member, tank armour, shell casings and the lead from the truck batteries. The ingenuity of the mechanics was plain to see. Land Rovers, criticised for being underpowered, were being fitted with more powerful 6-cylinder Toyota engines, while their own engines were bored out to increase their cylinder capacity from 1600cc. to 2400cc. and fitted with larger diameter Toyota pistons (ibid.). Eritrean inventiveness encountered at the Suakin EPLF garage was again transparent. Normal trucks were being converted into oil tankers on site with the containers built from sheets of scrap metal. Trucks were being re-assembled using parts originating from different countries, with 'engine swapping' commonplace. The workers describe the hybrid results as 'Vodka-Cola' trucks, since most of the vehicles supplied to the Ethiopian government were American up to 1974 and Soviet after 1977, One of the workshops homemade creations was a tire vulcanising machine for re-treating truck tires. The Suakin mechanics had simply copied the principle from an imported model and built one themselves, which was operating adjacent to the original machine (ibid. p. 75-83)

Firebrace and Holland talking about the roads built by the EPLF said: "Within the limited technology at the EPLF's disposal, some of these roads represent major feats of engineering. The most dramatic route we travelled was the 'Challenge Road', cut in 1982 into the precipitous eastern slopes of Sahel mountains to give direct access to the Northeast Sahel front. This road twists and winds its way from valley floor to mountain ridge with 37 hairpins built over fortress-like supporting walls in a stretch of 12 km long. Swiss engineers, in peacetime, without air attack, would be proud of it (ibid. p.75).

The achievement made in health services by the EPLF was impressive. A 420-bed Central Hospital was built spread out over five kilometres of dry-mountain valley floor carefully hidden under trees or built into the hillside. It had operating theatres, surgical, medical, orthopaedic and obstetric wards, a special unit for facial injuries as well as laboratories and X-ray units, an ophthalmic unit, a dentistry unit and blood storage facility. There were also six regional hospitals, eight health centres, fifteen health stations and over 40 mobile teams, over 1500 'bare-foot doctors' and more than 140 village health workers and traditional midwives (ibid. p 102-111).

Based on their study Firebrace and Holland concluded: "In spite of the severe difficulties imposed by the war, the EPLF has established a substantial light industrial sector in the base areas. Industrial development in Eritrea will face a very different set of problems when peaceful solution is finally found. But the EPLF's achievements to date provide a strong argument within the overall case for the economic viability of the future self-governing Eritrea" (ibid. p.83).

The paradox in the Eritrean case is that destruction and construction, though in different scale, seem to go parallel. You see the industrial base built during the 1940s, 50s and 60s being destroyed during the 30-year war of liberation. At the same time, a new sense of confidence in ones own capabilities and the learning and building from the bush is the new hope for a new foundation of future technological development of the country through enterprising and innovation for survival. This is the seed of hope of the country. IT is based on a culture of endurance and continuous learning, which are at the base of every knowledge and innovation.

Current Profile of Eritrea

The principle of 'self-reliance' that evolved and grew during the war of liberation, is still present more than ever in this newly independent country. It is not difficult to understand the strong roots it has in the minds of the leadership of the country. In a recent interview, President Isaias Afewerki said: "Billions of dollars have been spent in cases like Somalia, Cambodia. Where have these billions gone and how society benefited? And what can the international community or the UN claim was achieved? Is it peace or the transformation of living standards? Nothing has changed. In fact, the international community has created institutions that give the false impression of resolving problems but in fact only perpetuate problems and create parasites" (Eritrean Profile, March 21, 1998).

In today's world, nobody seems to believe in the internal capacities of the developing countries to solve their economic, social and political problems. As a result of these, the international community usually prescribes solutions for them but the cure has not been found yet. This small country is challenging that way of thinking. It is shouting and saying: "We can do it on our own if you could only believe in us and give us the chance to do it on our own!" This is why the Eritrean President said: "Aid should be a temporary dose, like aspirin, or a temporary drug with appropriate regulations to limit the time frame for its dosage or you will get a habit. It is better to take a bitter pill to cure the disease rather than have false drugs that will develop the habit of dependency" (ibid.).

The Eritrean leadership, according to some political economy analysts, has taken a 'risky decision' while to others a 'brave decision' with regard to aid by altogether scratching it from their vocabulary as a debilitating and crippling factor. Many do not believe that Eritrea can rebuild its economy, national infrastructure, agriculture, industry and social fabric that have all been destroyed during the war without much 'aid'. To them this concept of 'self-reliance' is considered to be a 'folly and bad experiment' that puts at stake the very future of the Eritrean people. On the other side those who take it as a 'reasonable and courageous decision' they support it in view of all the failed aid projects in Africa and elsewhere in the developing world.

Nobody thinks the fact that looking into one's own resources within one's own nation is a weakness. But to base one's own development on aid goes against the building of nations on the simple fact that with aid non-government organisations and charities that do the job on behalf of society and governments abound crippling the development of national institutions hence reinforcing the cycle of dependence.

The Eritrean way of thinking and doing is to lay the foundation on self-reliance where aid could be an element to support the building of institutions and the development of skilled manpower by participating in the different projects and programmes. It negates the idea of aid as the foundation of development. Eritrea does have an established tradition of self-reliance. It suits it to build on it. Of course, there has been a lot of controversy about this concept. But Eritrean leadership, trained pragmatically in the long war of liberation, find it unconvincing that aid with the strings attached to it could really solve their national problems. The fact that they have been able to challenge one of the biggest armies in Africa, with all its resources, by relying on themselves economically and militarily, have built a very strong sense of self-confidence that no theory can shake away. This is what the President of Eritrea said defending the idea of self-reliance: "We learned the hard way. During the war, no one supported us. When (Emperor) Hailesellasie was in Ethiopia, the United States supported Ethiopia. Then Mengistu overthrew Hailesellasie and allied with the Soviet Union. All that time, we got nothing from the US or then the Soviet Union. So we had to find a way to achieve our goals by relying on our own resources. Now the benefit of that experience prevails: We can do it on our own" (ibid.).

By some, it has been interpreted as arrogance to say no to some kind of 'aid'. For them a beggar has no choice but to accept everything offered to him. But the Eritrean leadership does not consider itself as beggar. Eritrean leaders firmly believe that they are the owners of their own destiny. They have their own national development projects and will accept any aid that fits within these projects. Any other aid project that wants them to divert their focus and attention from their national priorities will not be accepted. To others, it may be even offensive to hear from the Eritreans statements like "Give us the fund and we will manage it ourselves." They want their own exports to do the job otherwise no fund is given. Is it a communication problem? Or, is it that donor agencies don't have confidence in the ability and integrity of recipients? It is both. Maybe it will take time for the Eritreans to sell their idea of 'aid' and their approach to development. They need also to learn how to effectively communicate and sell their new ideas.

We have seen in the first part of this section that Eritrea's industrial development was going backwards because of war and deliberate neglect by the Ethiopian government. As a result, the relatively advanced industrial base developed during the 1930s and 40s was virtually lost. The few remaining enterprises are working on very old technologies of the said era.

Now the government is working hard to attract foreign investment by creating an investment conducive environment. Direct foreign investments and joint ventures are slowly growing, for example the old Coca Cola factory is being modernised and expanded by a joint venture between the Government and the Coca Cola Company of USA. Rothmans Cigarette Company has purchased the Gash Cigarette Factory. Eritrean capitalists in Diaspora are also investing in these privatised companies such as Asmara Sweater Factory and Mereb Textile Factory. Anadarco, an American oil company, is doing oil explorations in the Red Sea, Keangnam, South Korean construction firm (part of Daewoo conglomerate) is operating in the country in big construction works. Others are in the making like the joint venture in telecommunications between Daewoo of South Korea and the Telecommunications Services of Eritrea, a government owned company.

Most of the public enterprises are in the process of privatisation. The government of Eritrea had inherited 42 public enterprises, which were nationalised by the Ethiopian government during the socialist regime (T. Haile, 1996: 67). First, the Eritrean government has decided to give full autonomy of operation to these enterprises in the hope that they become more competitive. But it was very difficult to bring the desired modernisation and competitiveness with lack of capital injection, skilled manpower, and capable and professional managers. Lately, the government has decided to privatise these enterprises and has already put 23 of them on the list for sale through auctioning, agreement between the two parties, partnership, the selling of .shares, rent and selling to workers and managers of these production centres (Eritrean Profile, vol. 3, No. 21). Already nineteen have been privatised by May 1999. Soon the remaining will follow. Everybody's hope is that this market economy system will bring healthy competition and attract foreign capital. This may lead to the modernisation of the Eritrean industries.

The study made by the Ministry of Trade and Industry in 1996 (Table 10.5) shows that the number of manufacturing enterprises grew from 958 in 1992 to 2443 in 1996, of which 46 were public enterprises. In 1996, 157 of these enterprises had i0 or more employees and the remaining were all small establishments with less than 10 employees (Ministry of Trade and Industry, 1998, p.3-a). Further, the study shows that in 1996 the manufacture of furniture was more than five times that of 1992, in terms of number of establishments. Overall, the manufacturing industry grew 255 percent in number of establishments. The annual increase of gross output and input of manufacturing establishments of the country in the last five years was 22.1 and 29.5 percent respectively. While the added value of the manufacturing sector has increased by about 16.4 percent per annum. The 1996 total gross output of Eritrea's manufacturing establishment was 1080.14 million Nakfa out of which 53.7 percent was an intermediate input and the rest 46.3 percent was the value added at market prices contributed by the establishments (ibid, p. 1a).

Table 10.5: Manufacturing Sector of Eritrea, number of firms

Manufacturing Branch	1992	1993	1994	1995	1996
Manufacture of vegetable and animal oils and fats	16	16	17	20	39
Manufacture of grain mill products	295	399	516	553	624
Manufacture of bakery products	76	81	120	282	335
Manufacture of made-up textile, except apparel	11	11	11	11	11
Manufacture of knitted and crocheted fabrics and articles	89	86	88	97	102
Manufacture of footwear	20	20	22	49	55
Printing	12	12	15	14	11
Manufacture Soap detergents, cleaning & polishing preparations, perfumes and toilet preparations	25	25	25	23	21
Manufacture of other chemical products	24	28	32	38	41
Manufacture of glass and glass products	6	6	6	22	28
Manufacture of structural non-refractory clay and ceramic products	73	104	108	285	346
Manufacture of basic precious and non-ferrous metals	128	132	134	157	182
Manufacture of parts and accessories for motor vehicles and their engines	26	26	86	20	16
Manufacture of furniture	101	106	321	322	522
Others	50	57	72	118	110
Total	**958**	**1109**	**1573**	**2011**	**2443**

Source: Compiled from the Ministry of Trade and Industry Statistical Bulletin, *Results of the Survey of Eritrea's Manufacturing Industries, 1992-1996, p.3.*

In a recent study by Yacob Fisseha (1996) 'Micro, small, and medium enterprises in Eritrea' (MSMEs), it has been found that about three-fourths of the enterprises visited during the survey were of the micro group and the remaining were divided between the small (22%) and the medium (1%) sizes. In terms of the total employment among the sample enterprises, however, the micro-group accounts for only about a half while the small and the medium groups account for about 40 and 8 percent, respectively.

Based on the study it is estimated that nation-wide there are about 52,188 enterprises employing some 92,288 people, which accounts for approximately three-fourths of the country's total employment in the private sector, excluding fishing and traditional agricultural sectors (ibid., p.43). The percentage distribution of the 52,188 enterprises among the three basic size groups is 81.7 percent micro, 17,5 percent small, and 0.8 percent medium.24.2 percent are found to be in manufacturing, 60.5 percent in trade, and 15.3 percent in services. The urban localities account for 60% of these enterprises and for 69% of their employment. Asmara alone accounts for 30% of the number of enterprises and for almost 40% of the corresponding employment found in the whole country (ibid. p.38).

A large majority of the Eritrean MSMEs is young, with an average age of eight years. In fact, almost two-thirds of them (63.1%) were established since liberation. At the industrial level, the following groups have higher than the national average: auto repairs, 4.8 workers; catering, 4.0; fishery (not fishing per se) 2.7; metal works, 2.7; leather works, 2.5; and foods/drinks, 2.0. In terms of location, as one moves from the rural to the urban areas, the size of the labour force naturally gets bigger (ibid. p. 45).

The enterprises or industrial groups that experienced the highest growth in labour force size are: metal works (growth of 192%), and leather (113%) in manufacturing; fishery (175%) and leather or shoe retail

(164%) in trade; and auto repair (211%) in services. Finally, there is some clear-cut consistency among size groups: growth at every level of categorisation was higher for the bigger enterprises than that for the smaller ones, For example, for the three basic sizes, the growth rates in average labour size were 11 percent for micros, 76 percent for small, and 217 percent for the medium enterprises (ibid. p.47).

From the day of liberation in May 1991, the Eritrean Government has been working very hard to establish a conducive environment for the development of a market-led economy where the foreign direct investment is welcome, But encouraging investment in a vacuum is not possible, therefore the Government is trying its utmost in the building of the country's infrastructures, including an efficient and effective institutional capacity in the regulatory and legal environment. The whole legal system is being studied to introduce new laws capable of leading the country to the 2lst century. Some progress has been made in all sectors but a lot remains to be done. The greatest of which is development of skilled manpower for all sectors in the economy.

There is no question that the Eritrean government is delivering what it has promised in various projects undertaken. Western observers consider it an autocratic government that needs to go a long way to put democratic institutions in place but like its achievements, An ILO mission after investigating Eritrea wrote: "The mission found that Eritrea is perhaps the only country in sub-Saharan Africa to have successfully turned relief into development on a large scale"(ILO, 1995, p.99). Many western journalists as well have written about the corruption-free government of Eritrea. The recent IMF report says that Eritrea's GDP grew 8 percent in 1997. According to 1998/1999 World Development Report, per capita of Eritrea is US$ 210, almost double that of Ethiopia and approaching that of the Sudan. Life expectancy is 55 years, which is higher than that of Ethiopia (49) and Sudan (54). According to UNICEF April 1998 statistical information, Eritrean infant mortality rate has reached 78/000 while that of Ethiopia is I 131/000 and total gross primary enrolment rate for the country is now 51% as compared to 54% for the Sudan and 31% for Ethiopia. The enrolment rate for girls for Eritrea is 51% and that of Ethiopia and Sudan is 24% and 48% respectively. But access to safe water to Eritrean population is only 22% while that of Ethiopia and Sudan is 25% and 73% respectively.

In the last seven years, the country has made real progress in infrastructure development, production, employment, price stability, fiscal discipline, and accumulation of external reserves. During the period 1992-1997, real output growth averaged about seven percent. Annual average rate of inflation was maintained at less than 6.5 percent, The deficit from over 16 percent in 1996 was reduced to 5.5 percent of GNP in 1997 and gross reserves in months of import of goods and services increased to over six months in 1997. But now this promising progress made is threatened by the border conflict started in May 1998 with its neighbour Ethiopia.

No doubt Eritrea is one of the poorest and least developed countries in the world. It needs to break down this vicious circle of poverty and underdevelopment, and be able to give a decent standard of living to its people. It needs to catch up fast in order to share in the world's global economy. This has to be done within the context of high expectation of a people which has been deprived of everything because of manmade disasters, war, and a cycle of drought that has repeatedly hit the delicate natural environment of the Sahelian Region of Africa. Therefore, there is no time to waste. The Government should come up with concrete development policies to change this situation of economic and social underdevelopment.

According to the Government of the State of Eritrea Macro Policy (November 1994), the country has adopted a two-pronged approach to tackle the challenge of its socio-economic development. The first prong addresses the immediate problems of resuscitating the economy and rehabilitating certain sectors through a programme of recovery and rehabilitation. The second prong addresses the fundamental development problems and prospects of the country and charts the direction of its future growth.

This research is particularly addressing the second prong of long-term development problems. Being the national development objective to make the country "modern, technologically advanced and internationally competitive economy within the next two decades" (Macro Policy, p.10). Without dwelling in whether two decade time frame is reasonable or not, our main research question is to see how Eritrea could exploit the

opportunities offered by IT to strengthen its economic development in the shortest possible time.

Among the development objectives of Eritrea we find that the national development effort will be directed to the realisation of a developed capital, knowledge-intensive and export-oriented industries and services, and the development of a competitive regional financial centre. And under the Science and Technology Policy, the objective is said to be "to keep Eritrea abreast of developments in production, transport and service technologies in order to assure an upgraded and modern economic system that is competitive in the world" (p. 37). No matter how the national development objectives of Eritrea are over-ambitious in terms of time frame, it is a clear indication of the Eritrean leadership desire to cut corners in the process of economic development and the political will is there.

The growing evidence shows that Eritrean Government means business. The rapid progress made in infrastructure development achieved in education, health services, energy supply, and communications and transport after independence is a clear indication of the political will present in the country, For example, in a recent interview, Mr. William Anderson (outgoing head of USAID in Eritrea) gave his impression by saying: 'the government and the people have a very clear vision of where they want Eritrea to go and a strong determination to get there. In fact, in my 25 years work in development, I don't believe I have seen any people who have more clear vision or a great determination to achieve that vision as well as optimism that they would be there' (Eritrea Profile, Vof.6, No.13, June 5, 1999). Similarly WHO Country Representative, Mr. Elmi A. Duwale, said: 'I really think that the Government of Eritrea has done a quantum leap in the development of health services in such a short period of time. I have personally witnessed the development of health services in Africa for the last 30 years - first in my home country and then with WHO for the last 25 years from the biggest country Nigeria to Tanzania, Uganda and now Eritrea. I believe that what Eritrea has done in eight years was not achieved even in 20 years in most of these countries' (Eritrean Profile, Vol. 6, No.9, May 8, 1999).

To make sure that all the fever for development in Eritrea does not remain only a wishful thinking or a dream, a careful study is required to support the implementation of such a policy. Our study departs from the assumption that science and technology is the engine of development. IT is so pervasive and powerful technology that it is going to continue to reshape every aspect of human activity and occupy the central place in any development process in the 21st century. It is a powerful tool to learn with and work with in every field of human endeavour. Fortunately the cost of this technology is ever decreasing and has become affordable to households. And poor countries like Eritrea can benefit a lot in allocating part of the national infrastructure development budget to it. Our argument is that even a least developed country like Eritrea can greatly benefit by investing in modern digital telecommunications infrastructure as the basis for the national computer network and Internet to support the economy. This will enable the country's financial sector, the tourism sector, trade and industrial sector to become more competitive internationally. Improved social services through enhanced educational system, health system, culture and art, and environmental management would be possible.

Knowledge is at the basis of any development process. Our modern times more than any other era has acquired a tremendous power of knowledge generation, which is mostly attributed to science and technology development in particular that of IT. The last four decades have witnessed the information technology revolution. Mankind has amassed huge capability in information processing, storage, and communication, This in turn has increased the rate of knowledge generation and thus of innovations and development. But this capability is only found in the developed world and not in the less developed world like Eritrea. The more time passes and nothing is done the gap between the developed and the less developed world is going to increase.

To redress this unfavourable situation, Eritrea must act quickly to develop the necessary infrastructure for the development of science and technology. This starts with the right science and technology policy choice and institutional capability development to implement it. Eritrea immediately needs to develop the ability to select and effectively use technologies that can make the most impact on its development. One such technology, the author thinks, is information technology.

10.3 S&T policy

Eritrea believes (Macro Policy, 1994, p.30) that the 1,200km coastline and over 300 islands of different sizes are adequate grounds for the development of tourism and port services. Eritrea’s location at the crossroads to Europe and the Far East places it in a position to access important global as well as regional markets for both inputs and outputs. The country's strategic location is expected to be contributing factor in the attraction of foreign business wishing to access the various markets. As a result becoming a trade, tourism and service- hub in the region are considered the future of the country.

The explicit S&T policy-making mechanism is yet rudimentary. But there are fiscal policies to encourage the investment on new technology and the government attitude is very pragmatic. The concept of self-reliance of the war of liberation is very much alive. Dependence on one's own resources and people is pushing the country to learn fast. The country needs more time to mature and come with a clear picture and structure for a systematic acquisition and diffusion of the necessary advanced technology.

What we are witnessing in Eritrea is only the beginning of the technological transfer'. New technologies are coming in the country but to master it requires time. The more advanced technology the newly established firms import, the more they are dependent on foreign inputs in terms of spare parts, materials and technical assistance. It is widely accepted that to limit such dependency, every developing country should establish S&T institutions to help accelerate the adoption and diffusion of critical technology. An industry matures technologically if it is able only to sustain itself without much dependence from the outside. In other words, a network of adequate number of customers and suppliers should exist to make vertical integration possible. At the same time, related industries should also be equally developed to exploit possible synergy and the possible fertilisation of new hybrid of firms and industry. It is within this framework that we need to see S&T policy-making body to contribute by creating a conducive-environment for the creation of critical industries and the diffusion of critical S&T in the country for mature industries to emerge.

The service sector in general is information intensive activity. Sea ports, airports, trade in general, banks, insurance, and transport are today based on information technology. A regional service-hub without information technology is unthinkable. Therefore, because, on the one hand it is a pervasive technology of the future and on the other hand is the basis of the service sector, information technology is considered to deserve a particular attention in the development of Eritrea. In the country there is not yet any systematic way of diffusing and using IT for creating a competitive advantage. In this chapter we will see S&T in general, in the next chapter IT diffusion in the country, and finally in the chapter on the 'future of Eritrea', we will argue for the strategic importance of IT for the country's future development.

Vision and goals

Let us start our presentation from the socio-economic development vision and goals of the country. Later on, we will try to link it to S&T in relation to these development goals. The Government of the State of Eritrea in its Macro Policy of 1994 has adopted the following national development objectives:

- Improved agricultural production through the development of irrigated agriculture, and by enhancing the productivity of peasants, pastoralists and agro-pastoralists.
- Developed capital and knowledge-intensive and export-oriented industries and services.
- An upgraded and technologically improved informal sector (micro enterprises now on the margin of the formal economic structure).
- A developed tourism sector and high-grade conference and convention facilities.
- A competitive international financial centre.
- A developed and systematic public health-care system.
- Broad-based education incorporating widespread dissemination of skills and languages and extensive human capital formation.
- An effective social welfare and safety net system.
- An upgraded and safeguarded environment that is free from pollution.
- A decentralised and democratic political system.
- An internally peaceful and stable nation at peace and in harmony with its neighbours.
- A free and sovereign state where human rights are respected.

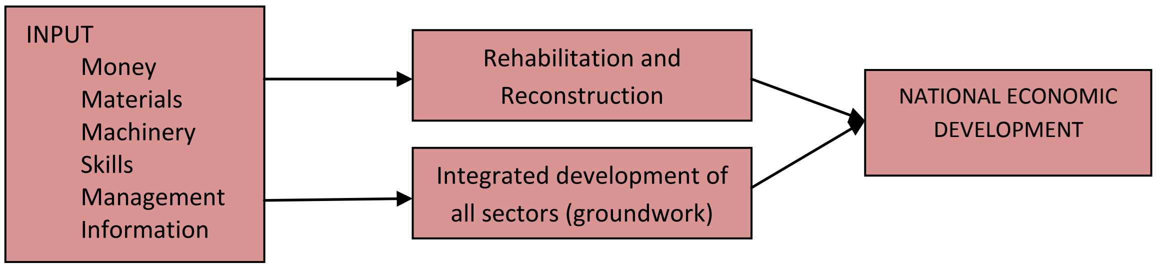
Based on these development objectives, it is not difficult to derive the S&T objectives of the country. In fact, the list of development objectives starts with a very important statement, which says: "The overriding national objective is the creation of a modern, technologically advanced and internationally competitive economy within the next two decades." It is really a very great challenge to achieve this. But the Eritrean Government seems to be determined to cut all possible corners to achieve it. To achieve the above stated objectives broad-based growth strategies have been adopted. This is to mean that rehabilitation and reconstruction on the one hand and an integrated development in all sectors on the other hand will be undertaken in parallel (see Figure 10.1).

The current S&T policies are too broadly defined. The objectives are mostly implied. Some of the implied S&T objectives in the agricultural sector are drip-irrigation system, use of improved seeds, improved breeds in the animal husbandry and poultry, pest control and animal disease control (including immunisation technologies), introduction of modern storage facilities, food security information system, and the introduction of a modern mechanised agricultural system.

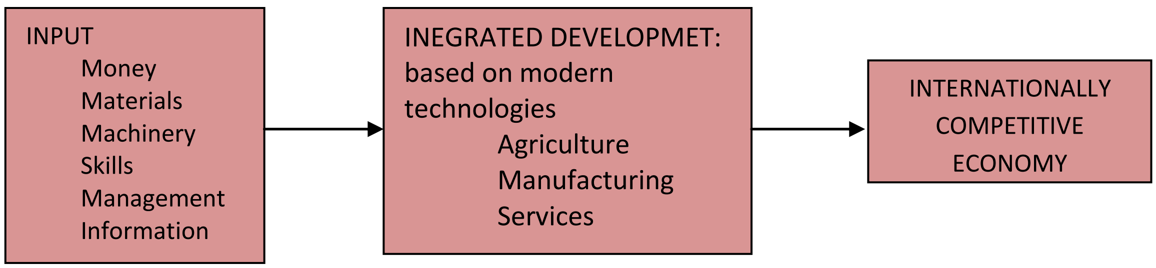
Knowledge-intensive industries are mentioned but we can only guess to what it may mean. It may mean computer software industry or engineering plants and firms, or petrochemical and chemical industries or others. This needs to be more specific.

Figure 10. I: The integrated development plan

PHASE I



PHASE II



In the tourism sector specifically high-grade conference and convention facilities are mentioned but there are many others implied like the different types of star hotels and catering services of international standard. A modern tourism industry is highly dependent on modern transport and communications systems as well as professional management and marketing skills. In here, the information and communications infrastructures are very important and IT is the sine qua non technology.

To achieve the economic objective of developing a financial centre of international standard, the objective of S&T should be the development of IT of relevance to the financial systems. This is highly dependent on communications and information infrastructure development. It requires also highly skilled manpower with international experience. This objective assumes also the ability of the country to attract international financial institutions. It could aim for a more modest regional financial centre development of international standard.

All of these major economic development expectations can only be realised with extensive human capital formation and thus the education system has to extensively expanded and modernised. The same applies to the health services. The challenge faced will be how to get money to invest on these social sectors.

Finally, one of the major objectives of saving the environment from pollution requires Eritrea not to become a dumping area for old and polluting technologies escaping the more stringent environment protection laws in the developed world. That is, Eritrea is going deliberately on more advanced and less polluting technologies but more expensive than the older technologies. So far, the facts show how difficult it is for developing countries to achieve this ambitious objective. For example, in Eritrea car pollution has increased during the last seven years because the country had become the dumping place for second hand cars, trucks and buses. Definitely with the present regime of car pollution control regulation, the environment cannot be protected from air pollution.

To conclude, in Eritrea explicit S&T objectives are missing and the few times that are mentioned are very broad and at times vague. There is a clear need of explicit and specific S&T objectives for specific sectors and for the general national infrastructure as a whole in order to concretely support the implementation of the national social and economic development objectives.

S&T policy

UNESCO S&T model, as we have already seen in chapter six, proposed five functional activities such as: planning, co-ordination, implementation, advice and advocacy. It advises that such an institution be placed in the office of the Head of the State under the direction and supervision of the president of the country himself. In Eritrea the National Development responsibility is divided among the Office of the President, Ministries and Government Authorities (see Box 10.1).

The Macroeconomic Management develops and maintains national strategic economic reconstruction policies that establish the priorities for the Government's long term investment, monetary, fiscal, trade, co-operation and institutional objectives regarding the Nation's management and administrative systems. This activity is managed by the Office of the President and Ministry of Finance and Development through a Working Committee comprised of Ministry of Finance and Development, Ministry of Industry and Trade, Ministry of Tourism, Ministry of External Affairs, and Bank of Eritrea (ibid, p, 6).

The Strategic Economic Planning establishes national, provincial, regional and sector indicative planning objectives consistent with the Government's long and medium term development plans, and issue indicative national planning guidelines for the next year to ministries, enterprises, and agencies. This activity is the responsibility of Office of the President, Strategic Planning and International Economic Co-operation Department in consultation with the Ministry of Local Government and central agencies (ibid. p. 7).

The organ of the State of Eritrea Government responsible for the S&T policy-making, by default, seems to be the Office of the President, Strategic Planning and International Economic Co-operation Department. The line ministries have established their respective 'Research and Training Departments', but they do not have policy guidelines with regard to S&T priorities which should be given by this office. Why is this vacuum created? It may be because, at the present time, the country's priorities are in rehabilitation and reconstruction. The need of priorities and guidelines is not yet felt. After not too long, the lack of it will create duplication and problems of co-ordination. Now, these research departments are only established with one or two people working without any real long-term research agenda. The lack of skilled and experienced manpower and research budget is their greatest stumbling block.

Therefore, in Eritrea there is not a separate S&T policy making body. Research activities are decentralised at ministerial level as we have already said above. In the new government structure, each ministry has a department of research and training. These departments are new and are still to be staffed with appropriate skilled personnel and the necessary budget to carry on their new duties. The exception to this is the Ministry of Agriculture and the Ministry of Energy and Mines where they have started to function, though, in a limited sense. It is unrealistic to expect much from these institutions in the near future for they are badly equipped to do the job. There is a critical shortage of highly trained manpower in all fields; there is also problem of getting funds from the government for research purposes, as the country is in a transitional period of economic rehabilitation after a long war of liberation and money is in short supply.

Table 10.6: Office of the President, Ministries and Authorities responsibilities

Office of the President responsible for strategic planning such as:

1. Macro Economic Management
2. Strategic Economic Planning

Ministry of Finance and Development for resource allocation and estimate process:

3. Medium term Forecasting
4. Public Investment Program
5. Develop Projects
6. Short Term Forecasts
7. Capital allocations
8. Budget Call
9. Budget Hearings
10. Budge(Background Paper
11. Preliminary Consolidated Budget
12. Prepare Estimates & Budget Speech

Line Ministries for programme management:

13. Compliance with Estimates

Bank of Eritrea and Ministry of Finance and Development for post assessment:

14. Quarterly Reviews

National Credit & Monetary Studies

Source: Working Protocol between Strategic Planning & International Economic Co-operation Department, Ministry of Finance and Development, Ministry of Foreign Affairs, and the Bank of Eritrea, January 1994, p 32.

Even the University of Asmara has not been able to carry out research programmes on a sustainable basis in some selected areas with potential of solving social and technological problems of the country. Suffice to say that the University of Asmara with a newly established engineering programme, only three years old, cannot undertake a leading role in the development and diffusion of technology in the country immediately. It has started with a 3-year diploma programme in civil, mechanical and electrical engineering, and it upgraded to degree programme in 1999. The country had the first batch of48 engineering graduates from the three departments on July 4, 1998. More needs to be done before this College of Engineering can play a role in leading and supporting the industry in the development of industrial technology for economic development.

It does not mean, though, that in the private sector the small entrepreneurs are not actively engaged in creative innovations to satisfy some of the basic needs of the Eritrean society particularly in metal and wood works, in mechanical repair services, and home-made spare parts.

In Eritrea everybody speaks of technology and technological development. New technology in construction industry, computerisation in offices and factories, modern machinery in factories, etc. 'Modern farming technologies' is currently the buzzword in the country. Some initial indications of introducing the drip-irrigation technology are evident. For example we have it in one flower-farm near Asmara, in another banana farm in the Gash-Barka region, another in the Eastern lowlands in Gahtelay farm. Similarly it is possible to mention other examples from the industry such as the new marble manufacturing plant in Ghinda, the Fred Hollows IOF Laboratory (Lenses manufacturing plant, a high-tech firm), ASBECO asphalt making construction firm, etc. [n the services sector in the Photo and Video services, tens of firms have introduced modern computer processing technologies. It is also impressive the number of computers for office automation in the country since 1992.

It is not uncommon to see Eritreans returning from the Diaspora with certain skills and technological know-how working hard to establish small firms based on modern technologies. It is not uncommon also to hear them complaining about the absence of institutions able to give required support, absence of skilled manpower, lack of adequate infrastructures, like communications and transport systems, to enable them to benefit from international connectivity.

It is no wonder that Eritrea, as a newly emerging country from the ashes of a 30 year long war of liberation, lacks the necessary resources to establish S&T institutions. There is no adequate number of highly skilled technical manpower and professional management and administrative body with the necessary experience to run such institutions. Money is also in short supply to establish even some long overdue support institutions. Thus, for the foreseeable future, research activities may remain an insignificant portion of the university's activities and other institutes or government agencies. Here, a dose of foreign aid could be administered to institutionalise research activities and develop a good base for a research culture to develop in the country.

We have said that there are not yet systematic R&D activities nor, for that matter, a systematic promotion and diffusion of S&T in the country. There are few fragmented and isolated instances of research activities going on, for example research on renewable energy development in the Department of Energy. In the Ministry of Agriculture research on pest control, water and soil conservation, improvement of seeds and animal disease control are carried out on a limited basis. There are a small number of research activities in various ministries, particularly dealing with various assessments of social and economic profiles of the country. Where do they all fit? How could they be co-ordinated? Is there any continuity? How could the information be effectively used and disseminated? AU of these and similar questions could be addressed by S&T policy analysis and would lay the necessary foundation for effective and efficient management of science and technology.

Some may argue that the process of S&T policy making is costly and the country does not have the luxury of spending such money. But the answer is simple. If the country is dealing with machinery and know-how in the day to day activities, which it is, then to ask which machinery to buy, how to effectively adapt and maintain them, how to develop the necessary skills required is not out of place. Entrepreneurs can do something about it but not all. Their capabilities as individuals are limited. The incentive to do it is not always there because they are, most of the times, after quick returns. But the changes we are talking about to bring in the country are not possible by simply leaving the things to market forces. Our small entrepreneurs don't have the experience, nor the knowledge and the money to undertake it on their own. It is here where the national policies come into picture, to act as a force to coordinate, guide and promote the creation and diffusion of technologies that can make the difference to improve and the change the living standards of the country,

Below, an assessment of what is going on in practice in the country in the various sectors is given.

10.4 Institutional capability

From Science & Technology point of view, Eritrean institutional capacity can be analysed following the UNECA (1991) discussion which looks at it from three perspectives: the universities, the industrial research and development institutes, and the enterprises.

In Eritrea there is only one university, University of Asmara. This institution in terms of year of establishment is one of the oldest universities in the continent. The catholic nuns, Comboni Sisters, established it in 1958. But because of the political problems in the country, it could hardly grow. It was established during the Eritro-Ethiopian Federal Government. Soon followed the annexation of Eritrea to Ethiopia by force in 1961. The Hailesellasie regime did everything it could to marginalize it. The fear was that it might become the centre of Eritrean students' political struggle. The whole trick was to disperse Eritrean students in Ethiopian higher institutions so that the best brains are trained and possibly retained in Ethiopia and in the long run dilute the national identity of the Eritreans. But this strategy did not work fully because the very students that have joined Addis Ababa University continued their political struggle in Ethiopia. And at one point, a significant group of them joined the armed struggle of Eritrea, eventually becoming the leaders of the armed struggle.

When one tries to look at the possible gap that might exist between the national development plans and their translation into national technological plans from which researchers can select R & D programmes, this becomes a very difficult task because such explicit plans are nonexistent. The national development plans are, at best, incomplete and less articulate. This may be because the country was mainly taken up by the rehabilitation and reconstruction phase. But now the country is entering into a new phase of the development stage and articulate national economic plans are needed very much. There is a need for national technological plans that could be the basis for the selection of R & D programmes. At present there is no clear basis for research selection at the university and other institutes or agencies. The broad science and technology mentioned in the Macro Policy (1994) or in some other proclamations do not constitute a national technological plan. An immediate action should be taken to fill this vacuum.

Collaboration between the university and other relevant authorities to train the required manpower with specific status and skills needed to implement technology plans within a given time does not exist simply because the university itself is not sufficiently endowed to do so. In fact, the Engineering College is only three years old. It has started with a diploma programme now upgraded into a degree programme. It is only focusing on teaching. It needs some time before it can strengthen its departments with all necessary facilities such as experienced staff and other materials to embark on projects on specific skills training for implementing technology plans in the industry. But soon it needs to do something about it. The university has already accumulated some experience of collaborating with various government departments with regard to training in public administration, law and journalism and mass communications, archaeology and social works. Similar things can be arranged between the College of Engineering and the industry.

In the country there are very few institutes of technology having the competencies to appreciate the lengthy process and complexity of skills for the development of indigenous industrial technology. Industrial research and development institutes are completely absent in Eritrea. There is total absence of technology registry. There is lack of conscious effort to appreciate the inter-dependence that should exist between industry, science and technology institutions and policy makers. There is a lack of conscious effort and support to study, upgrade and adapt indigenous techniques to a level of mass production in industry. There is no funding for significant R & D. There is lack of employment opportunities in the industrial sector for people such as chemists, physicists, mechanical engineers, with the exception of civil engineers, which are highly demanded at present time in the country. There is lack of competent policy-making body in industrial technology management.

It is not possible to talk of enterprises' contribution to the development of local capacity in R & D. First of all the industrial firms in Eritrea are very small in size and number; second, they are mainly light industries. What they do is import the machinery they need from abroad and try to produce and sell as much as they can. Their market is mainly the domestic market. At times some individual entrepreneurs succeed to make an imitated machine for their own use to replace the old one and save money on new machinery. Therefore, there is not a conscious effort to undertake research activity. There is little incentive and support given by the Government for the private enterprises to get involved in risky ventures of commercialising indigenous innovations and inventions. The Ministry of Industry and Trade was mainly engaged in the management of the 42 or so public enterprises inherited from the Ethiopian regime. But now, the Government is in the process of privatising these enterprises. In the near future it will have none to manage and will be freer to engage on promoting industrial technology in the true sense such as: making available of easy to assimilate technology, giving financial support for technical entrepreneurs, finding markets etc. A recent attempt by the Ministry of Trade and Industry to organise a technology exhibition, October 15-I7, 1998, was meant to redress this deficiency but more needs to be done.

10.5 Human capital formation

We know that human capital formation is at the basis of successful industrialisation process and technological development. Therefore, a focus on the human resources of Eritrea is the next logical step. Let us start from the very human resource policies of the country and its performance. The Macro Policy of the State of Eritrea (1994) gives the following objectives and policies:

I. Objectives

- To produce a population equipped with the necessary skills, knowledge and culture for a self reliant and modern economy,
- To develop self-consciousness and self motivation in its population to fight poverty, disease, and all the attendant causes of backwardness and ignorance.
- To make basic education available to all.

2. Policies

- Universal primary education up to seven years will gradually be made available to all,
- Skilled manpower requirements of both the public and private sectors will be met by a steadily increasing enrolments at the secondary, technical and vocational schools,
- Continuing education through formal and informal channels will be promoted to achieve higher literacy rates and enhanced competence,
- Tertiary education will be expanded selectively to meet the envisaged manpower requirements of the country. For diversified skill acquisition, this will be supplemented by utilising training opportunities afforded by the international community,
- The emphasis of technical/vocational training will be the imparting multi-craft dexterity and skills that enhance the job adaptability and retraining potential of the student,

- The Government, the community and the direct beneficiaries will be made to contribute varying amounts towards financing educational costs. The Government may resort to levying surcharges to meet part of the costs of education,
- Official recognition and/or professional accreditation of skills and academic attainment will be awarded only after undergoing government established certification procedures,
- There will be no restraint on the provision of education by the private sector,
- The standards of private schools will be maintained by curricula issued by the Ministry of Education. Private schools are expected to follow this curriculum but they will not be limited by its coverage,
- Non-secular schools will be given accreditation of professional competence (in nonreligious matters) only after completion of established national certification procedures (Macro Policy, 1994, p.39-40).

The present Eritrean Government has made it clear from the very beginning that human resource development will be given priority. In fact, the Macro Policy (1994) has declared that universal primary education up to seven years will gradually be made available to all.

A skilled manpower need of the country is being progressively improved by increasing high-school enrolments, opening up more vocational and technical schools. Tertiary education is also expanding selectively.

The primary level net enrolment from 22.4 percent in 1991-92 increased to 28.8 percent in 1996-97. The net enrolment in the middle level has gone up from 7 to 7.9 percent; and that of second level education increased slowly from 8.6 percent to 10.4 percent. While gross enrolment was 51 percent, 30 percent and 16 percent in primary, middle, and secondary education in 1996-97.

Table 10.7: SCHOOLS 1988i89-1995/96 in Eritrea (Government and Private)

Level	Owner	Pre-liberation			Post-liberation				
		1988/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96
Primary	Gov't	162	141	137	258	342	385	405	442
	Non-Gov't	84	80	77	123	105	106	105	95
	Total	246	231	214	381	447	491	510	537
Middle	Gov't	42	37	37	47	46	55	68	72
	Non-Gov't	19	21	22	18	25	26	20	23
	Total	61	58	59	65	71	81	88	95
Secondary	Gov't	17	13	16	20	20	27	27	29
	Non-Gov't	4	4	3	5	7	6	6	7
	Total	21	17	19	25	27	33	33	36
Technical	Gov't	1	1	1	2	2	2	3	3
	Non-Gov't	-	-	-	-	-	-	-	-
	Total	1	1	1	2	2	2	3	3

Source: Eritrea: Basic Education Statistics and Essential Indicators 1995/96, Ministry of Education, 1996, p.17

The above table (Table 10.7) shows that the number of primary schools has increased 250.9 percent from that of the academic year 1990-91, the year immediately before liberation of Eritrea. While middle schools and secondary schools have increased by 161 and 189.5 percent respectively.

Total Government expenditures on education, without including expenditure for higher education, in 1992 was Birr 34.7 million, in 1993 Bin 46.3 million, in 1994 Birr 58.8 million, in 1995 Birr 90.3 million, and in

1996 Bin 91.0 million. Out of the 91 million spent in 1996, expenditure on salaries accounted about 57.6 percent.

.The technical and vocational education has expanded significantly in the past four years. In addition to the two intermediate level Technical Schools of Asmara and Winna, other two new private technical schools that of Pavoni and Don Bosco, at Asmara and Dekemhare respectively, have been opened recently. Several new vocational training centres providing courses of 6-8 months duration in a variety of skills are opened in various high schools across the country. In 199516 Asmara and Winna had 536 students out of which only 59 were female students. In the Asmara Comprehensive, Halai, Assab, Mai Habar, Mendefera, and Makalasi vocational short term training centres a total of 434 students graduated out of which 217 were females. In the Technical schools students are trained in general shop, general metal, machine shop, auto-mechanic, survey, drafting, wood, electricity, and radio. While the short term training in the various training centres were given in: wood work, construction, auto-mechanic, agriculture, electricity, metal works, plumbing, machine shop, and secretarial work.

If we try to observe the change of the last few years, we see that Asmara Technical School has graduated 594 from 1992-96, and that of Winna graduated 315 from 1991-95.

At the present time there are around 40,000 students in Eritrean high schools. This is only about 10 percent of the high school age population. If Eritrea wants to catch up in the coming 20 years, it should be able to put the 40,000 students of high school age to attend vocational and technical schools to achieve the level of the South East Asian tigers. We have already discussed about the need to put one in ten, like South Korea, of the 12-18 years old students in vocational and technical training (see chapter 6). If we take the capacity of Asmara Technical School, it was 410 in 1996-97 academic year. Assuming that we open a technical/vocational school of a capacity of 500 students, Eritrea would need to open at least two per year for the coming 20 years (40 schools) to be able to accommodate 10 percent of the high school age population. This is of course with assumption that by then the country will have high school enrolment rate of not less that 90 percent. If we take the apprenticeship prevalent, in the formal and informal sector, in the country into consideration, then, the number of such schools need be lower.

In a recent interview with the President of the country, Isaias Afewerki, the issue of human resource was raised and he clearly said that human resource is the comer stone of Eritrean development. In his own words: "Another dimension of our strategy is to develop human resources to the maximum. That may have come as a result of our recognition of the limitation of our natural resources. Without developing human capital, it is senseless. That is what we are doing now. Yes we need roads, bridges, airport, and water supply. But we cannot develop the infrastructure without developing our human capital. We are talking long-term strategy, 20-years. We have to educate our people." A successful arrangement with the World Bank on human resource development strategy was designed for the next five years. The Government of Eritrea has a plan within the coming five years to produce highly skilled manpower that could be flexible in accommodating or using whatever resources, internal or external, is available (Eritrea Profile, March 21, 1998, p.3). This project wants to produce about 500 in advanced degrees, i.e., Masters and Doctoral degrees, in all the critical field of studies where a nucleus of critical mass of highly educated people is required to enable the country's economy start become competitive in the 21st century. In line with the philosophy of self-reliance, the country wants to acquire soon in various areas a critical mass of expertise and liberate itself from dependency on foreign expertise. This by itself does not constitute the national human resource plan.

The national human resource plan, which is launched with the above-mentioned project, is going to address the clear mismatch between the existing training activities and the labour market needs. Therefore, the national human resource plan should be based on labour market information, otherwise soon the training may increase the number of unemployed educated people, Poor countries more than others should avoid 'training for unemployment' because there is scarcity of skilled manpower that needs to be filled. This can be achieved through a careful national human resources plan that does not assume the current and future demands for skilled labour in the economy is so great that there is no risk of over-supply.

Of course, the success of this kind of project depends very much on many other variables such as the ability to control brain-drain and effective and efficient utilisation of human resources through an enlightened human resource management. The development of such a critical mass of highly skilled manpower will be the basis of scientific and technological development of the country. In the mean time the country has started to employ a significant number of expatriates particularly from India and the Philippines for its high schools, the university, and other government departments. Hopefully this reliance on expatriate expertise will be limited to the short and intermediate term of the country's development.

University of Asmara is the only university in the country. It became a Chartered University in 1968. It became a state university in 1977 and came under the Ethiopian Commission for higher Education, supposedly to serve the Northern Regions of Ethiopia, Students were coming from every corner of Ethiopia. But this did not last long because the war of independence intensified in 1988 and 1989. Particularly when Massawa was captured in February 1990, the Minister of Education of Ethiopia decided against the will of the people to transfer it to Ethiopia in September 1990. The transfer lasted only less than a year since the transfer because Eritrea was totally liberated in May 1991. But the University's facilities were mostly transferred to Ethiopia and about 55 percent of its staff left because they were Ethiopians.

It is possible to say that the University of Asmara started afresh in September 1991 with a new group of fresh students, about 1,000. From only 13 degree- and diploma-awarding departments, the university grew to 26 departments with another three to start soon, among which is the department of Computer Science. The number of regular students grew from 1683 to 2908, i.e., it almost doubled but evening students have declined from 1259 to 188 because the programme has been phased out. The number of staff increased from 62 to 237 of whom 167 are Eritreans and expatriates are 70. But 62.8 percent of the Ph.D. holders are expatriates. The total number of degree graduates from 1991 to 1998 is 1602 of whom only 205 are females while the total number of diploma and certificate graduates is 843 of whom 220 females (University Statistical data). Based on the observation of the last seven years it is possible to arrive at an average number of graduates per year. By excluding the abnormal years, there have been about 400 in undergraduate degrees and about 100 diploma and certificate/year'. University of Asmara is still a small university and needs to grow fast to meet the growing demand for its services.

The 'publish or perish syndrome' is also present at the University of Asmara. This is because the policy of the university says that to climb the academic ranks one should publish in international journals. Nothing is said about possible contributions to local industrial development. No scientific journal is yet published in the country. Unless change is brought soon, the heavy teaching load of teaching staff at the University does not allow the staff to engage in research activities hampering the growth opportunities of staff with possible serious negative effect on retaining them in the long term. Research facilities and funds with the institutional infrastructures need also be established. At present, it is not an exaggeration if we say that there is an insignificant research activity carried out by the University. It was only towards the end of 1997 that a research division has been established with an appointed head and slowly a University Research

Committee was established by the end of the first quarter of 1998. Hopefully this new structure will lay the foundation ground for research activity at the University.

It is very clear that Eritrea lacks the necessary human capital to make quick technological take off. But if the current commitment of the government on education and training continues, the country will soon have enough skilled manpower to sustain an economic recovery and development. It should not be forgotten that Eritrea has a great reserve of skilled manpower in Diaspora, A good policy to attract the Eritreans in the Diaspora will make the thing much easier for the country.

10.6 The Melting Pot: technology management and economic development

The cornerstone of Eritrean development policy is 'self-reliance' and 'avoid heavy borrowing'. Even 'Aid's not accepted with enthusiasm by Eritrean leadership as we have explained within the industrial history of the country in the chapter 1.

In construction industry new modern companies are emerging, for example Keangnam, Space 2001, Elmi, Raza Enterprises, Seghen, Ghedem, ASBECO and East Africa Construction etc. Interesting partnerships in jointly undertaking big construction projects, like road construction, is taking place. For example, a consortium of government and local private companies are jointly working on the highway construction of the road Keren-Tesseney (US$ 31.25 million). New restaurants and hotels are springing up all across the country. The mining sector is also slowly emerging, for now mostly doing exploratory activities.

The rebuilding of the totally destroyed Eritrean railway built by the Italians is another great example of Eritrean ingenuity and self-reliance strategy. Had it been done by foreign companies, it would cost US$ 200m. Today, about km 70 of the Massawa-Asmara railway has been rebuilt. David Hirst gave an account of it (Eritrean Profile, August l, 1998, first published in *The Daily Star*).In his words, "There can be few relics of the steam era like the 49-tonne Giovanni Ansaldo, Genoa 1937, or the 30-tonne Ernesto Breda, Milan 1927, outside museums, and surely none being restored as an integral part of a country transport system." Eritrean Railway boasts some 20 of these quaint machines. This transformation is led by old foremen trained during the Italian colonial period. It costs Eritrea nothing in foreign expertise, and a few million dollars for track-laying machine and a special, indispensable type of nuts and bolts. Seen from modernisation point of view, this is quite the opposite. But from the point of view of a poor and developing country doing it with only internal resources is nonetheless an achievement. There is no doubt it will contribute greatly in the development of tourism in Eritrea as a 'working museum'. It will promote also the hardworking character of the Eritrean worker more than any other effort to attract foreign investment.

With the recent revival of the fishing industry, exports started to increase amounting to 2,000 tonnes in 1994, and a similar amount in the first 8 months of 1995. But it is a very insignificant amount of the maximum sustainable yield of 70,000-100,000mt. The Ministry's plan is to increase industrial fisheries up to 15,000mt by 1999 through increased investment including joint ventures (Ministry of Marine Resources and Fisheries, Meeting of Eritrea's Development Partners, Asmara - Eritrea, November 2, 1998). They have started to introduce better fishing technologies but a lot remain to be done. The bulk of exports are bound for Saudi Arabia, Egypt, Ethiopia and Israel. Significant, unrecorded amount of fish continues to be sold in the Yemeni market via informal export traffic. Moreover, plans are underway to open the European markets to Eritrean marine products and some trial export has been attempted. It should be remembered that in the 1950s-1960s the Eritreans fisheries were a thriving industry. Annual catches of well over 25,000 tonnes were reported. Over 80% of this production consisted of pelagic - sardines and anchovy - which were processed into fishmeal or sun-dried for export for European and Far-Eastern markets.

In the development of the industrial technological base, the government is sticking to the principle of self-reliance which can be summarised as 'do it yourself if you can, learn to do it yourself as soon as you can, and modify things to suit your particular needs'. Investors are required to use expatriates only when skilled Eritreans are not available, even then, the expatriate experts should stay for the time necessary for Eritreans to take over.

It is interesting to observe the metalwork shops and mechanical repair service garages are very busy in trying to modify new model cars to suit the local needs. For older model cars, making the spare parts they need is not a problem. This shows only that the country was closed to transfer of the latest technology, particularly after the 1974 Ethiopian revolution. After 1991, all this is changing fast. A lot of new car models are flooding the country, new heavy and modern construction machinery are coming which is forcing the garages and machine shops to cope with the new changes in demand by introducing modern technology and skills.

The Medeber (in Asmara) compound, an area reserved for small metal and woodwork businesses, is one of the main supplier of local basic needs at the lower end of the market. It is not difficult to observe that entrepreneurial ingenuity is creating new products. Most of their products are household utensils, appliances, house furniture, metal or wood made doors and windows, etc. It is not rare to see these people to make their own simple machines, usually imitated products. It is a self-sustaining thieving business. In the past not much has been done to support these entrepreneurs.

The Eritrean Government had embarked upon a rehabilitation and reconstruction programme. In the last few years it has undertaken rehabilitation and renovation program of Massawa and Assab salt plants, Agordat fibre factory and tobacco plant, in the Western Lowlands, and rolling mill and are furnace in Asmara and Marble factory in Ghinda. Significant achievement has been made in the area of locally manufactured building materials as well. The construction industry is one of fastest growing sectors. A considerable build up of heavy modern construction machinery has been achieved in the last few years since independence. Together with it technical skills are in the increase.

The Department of Industry's objectives are to modernise existing industries and direct them toward becoming export enterprises. The Department aims at creating export-oriented industries, introducing appropriate technology and managerial know-how and improving the country's accumulation of foreign reserves for further expansion. New industries will be directed to rural areas in order to create jobs, indigenous technology will be made more competitive and conscious efforts will be made to promote women's participation in industry. Plans to decentralise as well as privatise the management of public enterprises will be put in place and current subsidies will be removed. Consequently, the role of the Government will merely be regulatory.

All of what we have seen above shows that the country is trying to transfer new technologies, adopt and adapt them to suit the country's needs, and diffuse them. This is happening in every sector. But it is not possible to say that there is any systematic diffusion of technology except that by induction, i.e. that of learning from the innovating film next door. Of course in all these, skilled Eritreans coming back from the Diaspora are contributing a lot in the process.

11

11. IT in Eritrea

11.1 Introduction

In the previous chapter, we have discussed about the broad S&T policy making process in Eritrea, the place of R&D in the government structure and the role it plays in the development of the country. Now it is time to focus on IT in particular. It is considered necessary to study the diffusion of IT in the country because it can help us understand the existing dynamics of this emerging industry. We can identify the major variables that are at play; the major problems that hinder the growth of this industry and see how far market forces alone can achieve in the context of a poorly endowed developing economy. This will enable us to chart the possible government intervention to complement the dynamics of the market forces to ensure a rapid development of IT to become an infrastructure backbone for the rapid development of the economy and global networking.

The chapter will start from the exploration of the diffusion of computers in various sectors and then move to IT policy analysis following the same structure in all the previous chapters with NIEs and SSA countries. We will see the diffusion of information technology in Eritrea. When we say information technology diffusion we mean what is happening in terms of computers and communications technology, institutional capacity development, human resource development, and the implementation of computerisation projects. We will try to analyse information technology transfer methods and the country's leapfrogging possibilities. This prepares the basis of a framework on which the country can base the development of this pervasive technology that will become the backbone of the entire economic system in the 2Ist century.

11.2 Environmental context

Microcomputers are invading the African continent. Eritrea is not the exception (see Table 11.1). The Customs Office of Eritrea has started taking record of data processing machines entering the country in 1995. It includes all computers, adding machines, and calculators. In value terms, these machines have more than doubled in 1997 (Birr 32,415,673) from that of 1995 (Birr 14,760,526).In the three years, from 1995-1997, a total of Birr 73,311,571 valued data processing machines have come to Eritrea.

Table 11.1: Data processing machines entering Eritrea in 1995-97 in value

Year	Quarter				
	1	2	3	4	Total
1995	5,278,044	2,798,036	3,462,743	3,221,703	14,760,526
1996	4,823,875	6,243,629	7,272,286	7,735,582	26,075,372
1997	8,092,711	6,507,772	10,428,404	7,446,786	32,475,673
Total	18,194,630	15,549,437	21,163,433	18,404,071	73,311,571

Source: Customs Office, Asmara Head Office, 1997.

To have a better look of the diffusion of computerisation process in Eritrea, a survey with a sample of 200 government and private organisations, most likely to use computers, was taken from which 176 (Table 11.2) responses were obtained. 81.25% (143) were having computers while the remaining 18.75% (33) did not have them. From those who do not have computers at present, 69.7% (23) said they need computers and 86.95% (20) of these are planning to buy within the next two years.

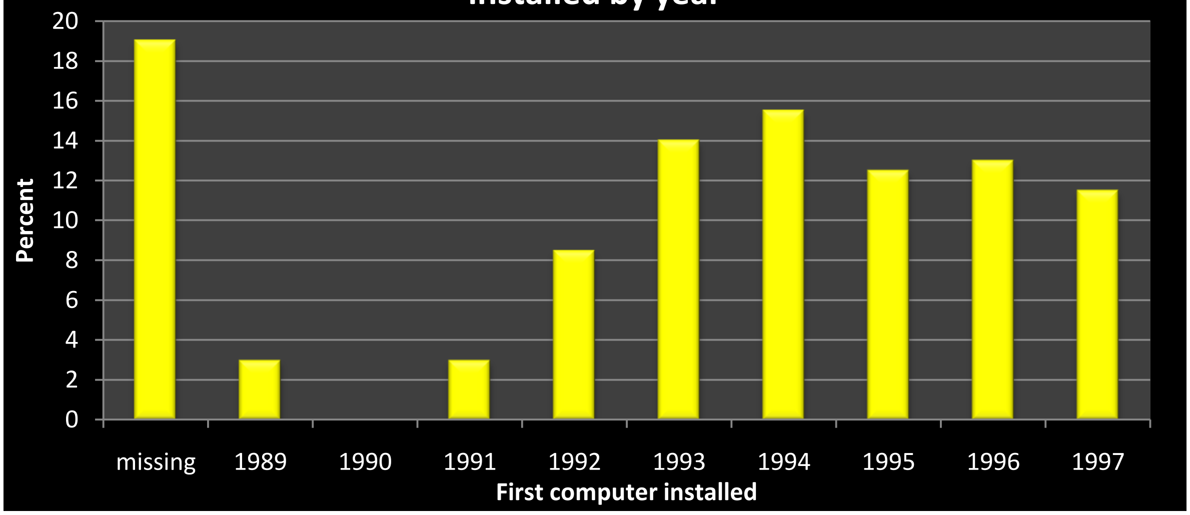
Table 11.2: Responding organisations classified by size (number of employees)

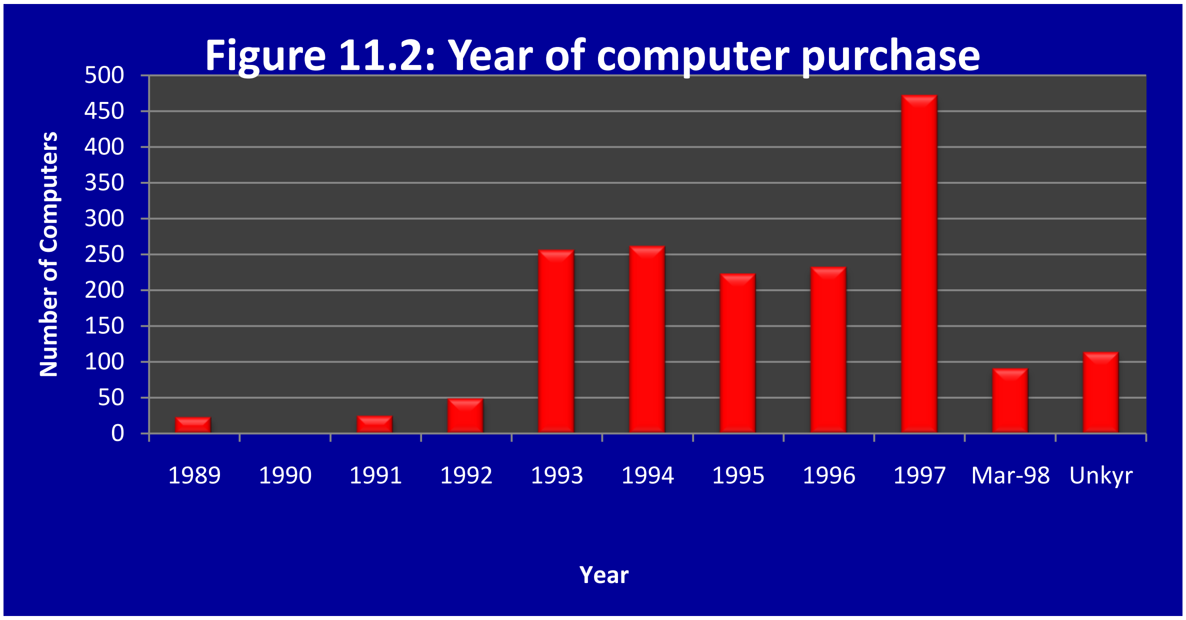
Organisations by type & size (No. Employ.)	Gov't	Private	International	Total
Micro (1-10)	7	38	2	47
Small (11-50	14	19	3	36
Medium (51-100)	11	7	-	18
Large (>100)	27	15	-	42
Total	59	79	5	143

Immediately after the end of the war of liberation, in 1991, it was impossible not to notice the increasing number of microcomputers entering the country. The first computers to arrive in Eritrea were in L984185 academic year at the University of Asmara as a part of a research project in the Department of Biology. They were four Mac PCs. The next computer was at the then National Bank of Ethiopia, Asmara Branch, in 1986. Few PCs were also introduced in EPLF head offices in Sahel after mid 1980s.

If we study the distribution of the first computer introduced in each of 143 organisations that have said they have computers, we find that the majority (19%) introduced computers for the first time in 1994, The early adopters (7%) have them in 1989 and 1991. The early majority (27.5%) appears in 1992 and 1993. The late majority (45.8%) seems to be almost equally distributed among the years 1995, 1996 and 1997. The 19 (10.8% of the 176) organisations that said will be going to buy within the next two years can be considered the laggards (see Figure 11.1).

Figure 11.1: Organizations and their first computers installed by year





The year 1989 signs the beginning of the arrival of a steady stream of computers in the country, 18 computers arrived at the University of Asmara in that year. No computers in 1990, it was the year Massawa was captured and all trade and communication was at a standstill in the whole country because of the war. After the liberation of the country, 24 May 1991, 25 more computers arrived in the country. In our survey of the 176 organisations, from 1992 to March 1998, in each year arrived 52, 246, 253, 212, 256, 446, and 141 respectively. In addition there were 103 more computers with unknown year of arrival. The total was 1740 computers within the surveyed organisations (.see Table 11.3 and figure 11.2).

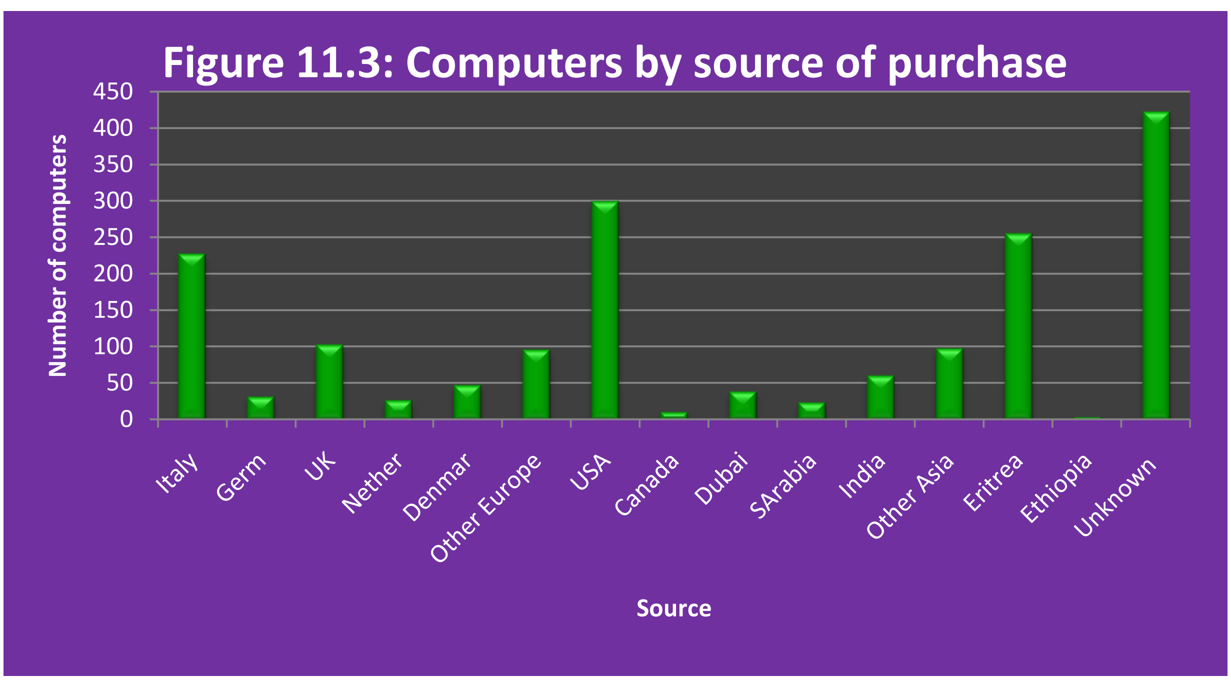


Table 11.3: Existing computers by source and year

Source	1989	1990	1991	1992	1993	1994	1995	19976	1997	Mar98	Unkyr	Total
Europe	2		12	13	133	59	55	108	97	41	13	533
Italy	-		12	6	107	9	31	46	9	7	-	227
Germ	-		-	-	3	2	3	3	21	-	-	32
UK	2		-	7	14	6	6	25	18	19	6	103
Nether	-		-	-	5	1	-	14	7	-	-	27
Denmar	-		-	-	-	4	10	-	34	-	-	48
Others	-		-	-	4	37	5	20	8	15	7	96
America	1		-	10	77	46	33	29	80	17	17	310
USA	1		-	9	77	43	32	27	77	16	17	299
Canada	-		-	1	-	3	1	2	3	1	-	11
Asia	-		-	5	19	64	27	16	23	7	61	222
Dubai	-		-	1	13	3	2	11	9	-	-	39
SArabia	-		-	4	6	-	8	-	4	2	-	24
India	-		-	-	-	61	-	-	-	-	-	61
Other	-		-	-	-	-	17	5	10	5	61	98
Africa	1		-	14	-	26	14	32	143	9	20	259
Eritrea	-		-	14	-	26	11	32	143	9	20	255
Ethiopia	1		-	-	-	-	3	-	-	-	-	4
Unknown source	19		13	7	27	68	94	47	128	17	3	421
Total	**23**		**25**	**49**	**256**	**261**	**223**	**232**	**471**	**91**	**114**	**1745**

The source of the computers is as follows: Europe 533 (30,54Eo) led by Italy 227 and U.K. 103; America 310 (17.77%) with USA accounting for most of it (299); Africa 259(14.84%) which is 255 from suppliers in Eritrea and four from Ethiopia; Asia 222 (12.72%) with India leading with 61 followed by Dubai 39 and Saudi Arabia 24; and other 421 (24.13%) from unidentified source (see Table 1 1.4 and Figure 11.3, 11.4).

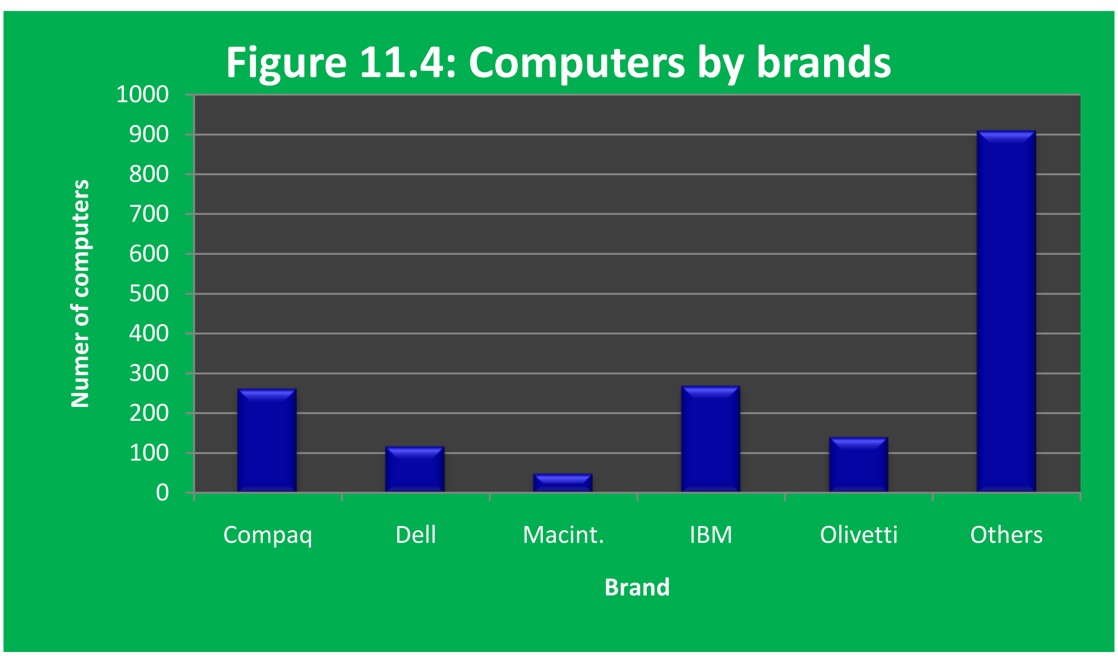


Table 11.4: Existing computers by source and brand

Brand & source	Compaq	Dell	Macint.	IBM	Olivetti	Others	Total	
Europe	**67**	**45**	**11**	**73**	**103**	**234**	**533**	**30.54%**
Italy	3	-	4	2	103	115	227	
Germ	5	12	-	3	-	12	32	
UK	49	-	-	21	-	33	103	
Nether	3	-	-	22	-	2	27	
Denmar	-	25	-	4	-	19	48	
Others	7	8	7	21	-	53	96	
America	**61**	**52**	**27**	**84**	**-**	**86**	**310**	**17.77%**
USA	61	52	24	83	-	79	299	
Canada	-	-	3	1	-	7	11	
Asia	**17**	**1**	**-**	**39**	**-**	**174**	**222**	**12.72%**
Dubai	6	-	-	10	-	23	39	
SArabia	6	-	-	10	-	8	24	
India	-	1	-	-	-	60	61	
Other	5	-	-	10	-	83	98	
Africa	**90**	**-**	**1**	**44**	**16**	**104**	**259**	**14.84%**
Eritrea	90	-	1	44	16	100	255	
Ethiopia	-	-	-	-	-	4	4	
Unknown source	27	19	10	38	21	306	421	24.13%
Total	**262**	**117**	**49**	**269**	**140**	**908**	**1745**	**100%**

When the computer brands have been analysed, the leading brands emerge to be IBM 269, Compaq 262, Olivetti 140, Dell 117, Macintosh 49 and the remaining 908 computers from other 63 brands. It shows the proliferation of computer brands which has a negative impact on supply and repair services (See Table 11.4; figure 11.4, and appendix 7).

The source of information of the purchased computer technology, in order of importance, is personal contact with distributors, donor agencies, local connections, consultants, and journals & magazines.

If we study the distribution of computers in the sample, Government civil services organisations are at the top with an average of 20.2 computers per organisation. This average is even higher than the average of the international organisations of 17.4 per organisation. 63.9 percent of the computers are found in the Government civil services even though the number of such organisations in the sample was only 31.3 percent of the total. This can be explained by the fact that those in the civil services are bigger in size while the private enterprises are dominated by the micro enterprises. The private enterprises average is 5.4 computers while that of the public enterprises was found to be the lowest 1.3 computers per organisation. In the sample 54.5 percent of the responding organisations were private enterprises but accounted only 29.7 percent of the identified computers (see Table 11.5).

Table 11.5: Distributions of computers among organizations

Types of organisations	Respondents		Computers		Employees		Average computers per organisation	Computer/ employee ratio
	No.	%	No.	%	No.	%		
Gov't civil service	55	31.3	1111	63.9	7382	35.1	20.2	1:6.6
Public enterprises	20	11.4	26	1.5	5297	25.2	1.3	1:204
Private enterprises	96	54.5	516	29.7	8224	39.1	5.4	1:16
PFDJ companies	11		57				5.2	
Computer business	27		290				10.7	
Consulting firms	14		62				4.4	
Manufacturing	17		49				2.9	
Others	27		58				2.1	
International	5	2.8	87	5	106	0.005	17.4	1:1.2
Total	**176**	**100**	**1740**	**100**	**21009**	**99.4**	**10.2**	**1:12**

But when we look at the computer employee ratio, we find a different view of the situation. In the international organisations we find one computer for 7.2 employees, almost one computer per employee. Next comes the Government Civil Services with 1 computer per 6.6 employees and the private enterprises, 1 computer is for 16 employees. The ratio of all the organisations in the survey was 1 computer per 12 employees while the lowest ratio is that of the public enterprises with 1 computer per 204 employees. This could be explained by the unwillingness of the Government to invest in them because they are in the process of privatisation but at the same time these are labour intensive type organisations.

Within the private enterprises, computer services companies have 56.2 percent of the computers while making only 28.1 percent of the number of companies in the sample. In fact, computer services companies and organisations, with an average of 10.7 per organisation, have the highest average next to civil service organisations and the international.

The computers are used for a variety of applications and the dominant ones have been found to be office administration, accounting, payroll, inventory management, record management, publishing, training, billing, work scheduling, production management, marketing and process control and others (33 were mentioned).

83.22% of the respondents are aware of package software suppliers, agents or sellers in the country while 33.57% only are aware of the presence of custom software making firms. There are no packaged software producers in the country. If there is a problem with commercial software package, a user company would usually get help, advice or technical support within the country 39.86%. Those who get it only sometimes are the majority 46.85%. Only 9.79% said they never get it. The nature and type of help, advice or technical support sought by the users can explain the difference in response. If these are simple and uncomplicated, then, getting help and support would be easier than when the situation is more complicated.

Suppliers of microcomputers, printers, tape/disk drivers, VDU terminals are now available in the country but of mainframe computers are unheard of, there was only one IBM minicomputer in the whole country, in the

Eritrean Electric Authority supplied by the IBM representative in the country. Getting from suppliers within the country 3 1/2" diskettes, magnetic tapes, continuous printer papers, toner for photocopier/laser, cables and connectors, fuses for electronic equipment, standard RAM chips, printer ribbons and the like is easy. Punched cards are not known in the country. Most of the respondents have never used 8" and 5 1/2" diskettes, magnetic tapes and standard RAM chips.

Table 11.6: Ease with which computer users get repair and maintenance services

Computer parts	Easy		Difficult		Impossible		Don't know		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Hard disk drive	46	32.17	65	45.45	10	6.99	22	15.38.	143	100
Floppy disk drives	50	34.97	61	42.66	9	6.29	23	16.08	143	100
Printers	71	49.65	56	39.16	3	2.10	13	9.09	143	100
VDU, terminal	30	20.98	59	41.26	17	11.89	37	25.87	143	100
CP	36	25.17	66	46.15	20	13.99	21	14.69	143	100

In general, it can be said that getting repair and maintenance services for hard disk drives, floppy disk drives, VDUs, and CPUs is difficult. Getting printers repaired is relatively easier, may be previous repair and maintenance skills in photocopy machines, typewriters and the likes could be easily transferred. It is encouraging to see those who say that it is impossible to get repair and maintenance services are below 14Vo for all the computer parts. But at the same time it can be easily noted that those who do not know, probably because they are new comers, are significant. Given that computer repair and maintenance services business at most is four/five years old, it is a big progress (see Table 11.6).

A very interesting character in the computer repair service business has been observed. Customers seem to be unwilling to pay the price for replacing a standard part as is done elsewhere in the world. The Eritrean market seems to be unable to bear. Therefore, the repair business is forced to look a way over it by repairing the malfunctioning part rather than replacing it. It is said to be cheaper but inconvenient because getting spare parts for such repairs is difficult.

At present there are no computer societies or clubs or user groups that could act as a source of information of computer technology and help in the diffusion of information technology. The major sources of information are the computer hardware/software suppliers (10.63%) with magazines and journals accounting for 22.38% of it.

The most popular and widely used software in the country are: Windows 95, MS Word, MS Excel, MS Access, MS Word 97, MS Excel 97, MS Access 97, dBase, Lotus 1-2-3, WordPerfect 6, and Graphics and CAD. In addition MS Publisher 97, Visual Basic 4, Application Generator/4Gls, Teleprocessing Monitors, Optimising Compilers, CASE and other 75 different types of software packages in use have been identified (Appendix 8).

During the 1993 and 1994, the first private computer schools appeared around the capital city of Asmara. These computer schools grew in number and size. Most of them started to give a number of other computer services such as: computer repair services, computer installation services, provision of computer supplies services, computer hardware/software sales services, and networking services. Now, their number fluctuates around 30, all in Asmara. Some of them have started to look outside the capital city by opening branches in other towns like Massawa and Keren.

Even though Eritrea had one of the most sophisticated telecommunication networks in the 1950s, today it has one of the least developed telecommunications infrastructures in the continent. Eritrean Telecommunication Services is the sole carrier in the country. It is the remains of the Ethiopian Telecommunication Services Asmara branch. Recently there was a joint venture to be signed between the South Korean Daewoo Company and the Eritrean Government. This move would have brought the required capital injection, technical and managerial expertise to the country. The Eritrean Government clearly said that the move was done to expand and modernise the telecommunication services infrastructure in the country. But the venture had encountered a number of difficulties. First it was the financial crisis in East Asia (South Korea) and then it was the turn of Eritrea because of the border conflict with Ethiopia. There is a possibility that it may fail.

The Government is hoping to link all the major towns in Eritrea in a telecommunication network based on the digital switching system. At present, only Massawa, Assab, Dekemhare, Mendefera, and Keren are in the network.

In the development of information technology, the ability to control physical environment factors such as temperature, humidity, and dust is very critical. At the same time infrastructure development such as the availability of regular supply of electricity, telecommunications infrastructure, hardware and software support services are of paramount importance. We can get some ideas of the situation in Eritrea from the Table 11.7

Table 11 7: Physical and infrastructure problems for computer users

Problem	Major		Minor		Mo Problem		Don't know		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Temperature	4	2.8	14	9.79	116	81.12	9	6.29	143	100
Humidity	5	3.5	11	7.69	119	83.22	8	5.59	143	100
Dust	44	30.77	56	39.16	43	30.07	-	-	143	100
Power supply	50	34.97	64	44.76	29	20.28	-	-	143	100
Telecommunication	21	14.69	31	21.68	48	33.57	43	30.07	143	100
Lack of hardware support	50	34.97	33	23.08	47	32.87	13	9.09	143	100
Lack of software support	38	26.57	36	25.17	51	35.66	18	12.59	143	100
Shortage of supplies	38	26.57	42	29.37	52	36.36	11	7.69	143	100

With regard to temperature and humidity the majority, 81.12 and 83.22 percent respectively, have said it is not a problem to the well functioning of computers. Even though a slight majority, 39.16 and 44.76 percent said that dust and power supply respectively are a minor problem, 30.77 and 34.97 percent respectively consider it a major problem and the rest consider it not a problem. This shows that dust and power supply are a major problem to some, to others a minor problem and still to others not a problem at all. May be this could be explained by difference in localities of the organisations. In some areas the supply of electricity is not regular because this infrastructure is being restructured and renovated. Dust could be less a problem if in the centre of the city rather than in the periphery because quality buildings and asphalt streets decrease the dust,

Telecommunications infrastructure is considered by a slight majority (33.57%) not a problem while about 3O.07% don't know what to say about it, may be because they are new in computer use or they do have stand alone workstations and have not yet considered networking. Those who consider it a major problem are only 14.69%, these are definitely the vanguard group who are looking for LANs and WANs and the lack of adequate telecommunications infrastructure is hampering their progress.

Shortage of supplies is not considered a problem by a slight majority (36.36%). While 29.37% considered it a minor problem, but still 26.57% considered it a major problem. This may be explained by the fact that the most common types of supplies are available but other specific and specialised type of supplies not for the mass market are not easy to get and have to be specifically ordered for the user, if requested. Since this is infrequently done they are not in priority list of importers and takes time to get them supplied from abroad. It is possible to say that the size of the market determines who gets the priority in the market.

With regard to hardware/software support, the respondents are almost equally divided among those who say that lack of hardware support is a major or not a problem (34.97% and 32.8'7% respectively). Again the possible explanation of this contradiction may lie in the fact that those who need the latest type of computer technology or computer systems would find it difficult to get adequate and quality support and services from within the country. While those who need less complicated support and services because of the simple computer system, they could not complain of the services and support they get locally. On the contrary, the majority (35.66%) of the respondents say that lack of software support is not a problem. Most probably because the software used is standard packaged purchased software.

Table 11.8: Time to get repair services

Time taken	No respondents	Percent
A week or less	44	30.77
1-2 weeks	34	23.78
3-4 weeks	23	16.08
1-2 months	10	6.99
3-4 months	7	4.90
5-6 months	2	1.40
>6 months	11	7.69
Don't know	12	8.39

To get some indicators of repair services efficiency, look at Table 11.8. Most of the repair services take 2 weeks or less, i.e.54.55%. Instances of repair services that take more than 6 months account for 7.69%, these are most likely not to be repaired at all. But it is also possible that when the level of expertise increases and more efficient computer repair services come into picture what thought unrepairable become repairable. For example, in the Business License Office there were five computers out of order. A number of computer technicians have tried and failed to repair them and they were lying idle for a number of months. Recently, they were all repaired by a new computer repair services business firm. This could be considered as an indicator of the low level of computer repair services, but at the same time competition is increasing in this sector and skills also are improving. There is no doubt in the very near future the computer repair service sector will be of a higher standard and quality.

Respondents when asked about the Government's help and involvement in the diffusion of computer technology in the country, they were almost equally divided into two groups with 44.76% for 'Yes' and 50.35% for 'No'. There is no doubt that those who said "Yes' are the government departments and public enterprises because they get help in training and consulting services from EISA (Eritrean Information Systems Agency), while on the other hand the private firms get no help in this respect and will say 'No'. The

Government gives help basically by giving training and sponsoring computer seminars. But all the respondents unanimously (97.90%) said that there is a real need of computers and that they do help in improving the productivity of the country. Probably this is an indicator that there is sufficient awareness for computerisation process in the country.

Therefore, it is possible to say that something is moving in the diffusion of information technology in Eritrea. International Agencies and the Government Civil Services are the driving forces. But with regard to support services, the private computer service businesses are playing a significant role, behind which the skilled Eritreans from the Diaspora are the main players. This trio: The Government, the International Agencies, and skill and money of Eritreans from the Diaspora should continue to work together to make it a sustainable development.

11.3 IT policy

Vision and goals

There is no IT plan in Eritrea. But something is moving toward that direction. Proclamation No. 53/1994, a proclamation to provide for the establishment of an EISA, is the first attempt of this. The IT objectives explicitly stated in this proclamation are:

- to introduce, adapt and diffuse the right information technologies in the country;
- to introduce and diffuse an appropriate set of policies and management practices for an effective and efficient application and exploitation of information technology in the civil service and all other economic sectors;
- to encourage the 'continuous learning culture' in Government and private sectors by establishing appropriate training centres;
- to develop enough human resource to support the information technology industry; to develop modern information networks in the country to make possible decentralised government and regionalisation feasible and effective;
- and, to make sure the quality of computer and communications services support available in the country is comparable to the international standards.

These objectives could be the basis for different kind of information technology projects and plans. It has to be noted, though, that the establishment of a body to look after the development of information technology of the civil services alone cannot make the country industrially competitive in the international market. If Eritrea's economy is an export-led free market system, it goes without saying that the private sector should grow in the use, adaptation and innovation in information technology. To make this possible, a very good strategy is required.

IT policy

The prevalent situation is that of 'laissez-fair' strategy, even though, some attempt is made to guide and standardise the kind of computer systems being introduced in the civil services through EISA. This was established by decree in 1994, as mentioned at the beginning of this section. It is under the direct control of the Office of the president. It was established as an autonomous entity of the State of Eritrea with two clear major objectives:

1. In the area of Policy and Co-ordination: Develop, advice, implement, co-ordinate and promulgate government information technology strategies, standards, policies and guidelines, and in particular (Proclamation No. 53/1994, p 6/7):

- to develop and promulgate a set of standards and supporting guidelines regarding government and public enterprise sector acquisition and maintenance of computers;
- to develop appropriate set of policies and management practices supporting more effective and efficient application and exploitation of information technology within the Government and the public enterprise sector;
- to develop and implement technical training programmes within the Government and public enterprise sectors, as well as develop programmes on improving and encouraging training delivery capacity within the private sector;
- to support other Government policies and priorities in the area of information technology, such as increasing computer accessibility, conversion to national script; regionalisation; private sector industrial development; research and development; the development of high priority Government and public sector management information systems (MIS); and general manpower development; and
- to give direction to private sector training operations in terms of curriculum and course content.

2. In the area of client services: Provide a range of information technology services and products to clients on a reimbursable basis, and in particular:

- to develop programmes and mechanisms to ensure acceptable quality in the delivery its services and products, and to ensure that there is an acceptable degree of client satisfaction;
- establish internal EISA human resources training and education of staff in order to ensure that the skills and educational requirements are commensurate with the clients demands for services; and
- implement internal technical resources bases and associated managed facilities in order that current and anticipated client demands are met in a cost effective manner.

EISA is still in the process of formation. This Agency is acting as computer consultant to government departments and as regulator of computerisation process in the civil services. It is managed by a Director appointed by the President of the State of Eritrea and responsible and accountable to the Office of the President. An Information Technology Policy Advisory Committee (ITPAC) is established to advise the President 'on all strategy and policy matters pertaining to information technology requiring the President's decision or approval under the Proclamation.' ITPAC is composed by five members: the Office of the President as chairperson; Ministry of Finance and Development, member; Ministry of Trade and Industry, member; Ministry of Education, member, and; Central Personnel Administration, member (ibid. p.9-10).

In EISA, at the time of the interview, there were one hardware maintenance technician, two computers applications experts, one database expert, two systems analysts & designers (including the Director), and a secretary. Two were on short term training in Germany while other two, University of Asmara fresh graduates, were recruited and getting on the job training. While the others are working only in the area of their expertise, the two systems analysts are multi-skilled. The Director of the Agency said that they could hire more computer professionals but there is not enough budget to do it. The Agency does not have the ability to cope with the increased demand of computer services in the civil service and public enterprises. At the time, it was focusing more on the regulatory aspect of their mandate rather than in the area of 'client services' or the technical support. 'So far we have sent to all ministries some general guidelines of how to introduce computer technology, Now we are in the process of revising a new guideline which soon will be communicated' (Interview, T. Ghebreab and Z. Abraham, October 13 and 29, 1997).

The powers of the Agency are given in the Proclamation No. 5311994.In general, it has the power to guide and regulate the import or transfer of computer and communications technology systems for the Government and the Public Enterprises. This is to make sure that standard and relevant technology is transferred in the country. But since the restructuring of the civil services, the Agency, from being an autonomous unit working like a parastatal, changed structure and came directly under the Office of the President. It was made clear by the Director that EISA does not have any relations with Communications Department. It is confined to computer services for the civil services.

In a recent Conference on Communications Policy organised by the Ministry of Information, from July 22-24, 1991 in Asmara, all the legal, cultural, technological, political and economic issues of national communications policy have been raised, debated and recommendation passed for the government to take action. It was an attempt to develop broad national framework that could integrate the various activities touched by communications. It is so vital in today's world that left to itself could only lead to fragmentation, inconsistencies, and poor co-ordination. So far, the government has not taken an integrated approach.

At the beginning EISA was an autonomous unit, financially self-sufficient and capable to generate its own revenues from its services. This went for one year and a half. But after the civil services restructuring, it came under the umbrella of the Office of the President. Now the practice of charging for services given is still there but collections are not made by the Agency and user departments are asked to make payments to the Ministry of Finance and Development directly. In the words of the Director 'at the beginning we were functioning more like a computer consultant in systems analysis & design and implementation working on a profit and loss basis. We were also doing some regulatory function. But today we are acting more like a regulating agency with some computer consulting services".

In the opinion of the Director the best way of organising the Agency would be to have two separate agencies: one to regulate information technology in general, and the other to give technical support and training in information technology. To implement the suggestion made above, the director continued 'I think that a national communications policy should be designed first. And then, based on the national communications policy, the government should establish the above mentioned agencies.'

With regard to the existing computer technical support in the country, in the view of the Director, some Eritrean IT professionals are coming from abroad. Some have established computer schools, computer consulting services, and some small software companies. Some of these don't work the whole year in the country because the market is not mature enough to keep them busy the whole year. Nonetheless, a number of computer companies have emerged such as EWAN, BIT, CTS, ETSS, ICET, Gelately Hanky, ERICOM 2000, K.M. Computers, IBM Tesat, TFanus, etc.

Even though something is emerging, it is not sufficient to adequately satisfy the emerging demand. That is why EISA is forced to engage itself in operational activities. But it is not appropriate for this Agency to be both a regulatory body and at the same time act as consultant or a computer service-giving organisation. Currently the Agency gives short-term computer training, such as applications software (one month training); systems networking (one month training); and database applications programming (two months training).

The most critical computer skill the country needs, according to the EISA Director, is systems analyst & designer. The Director noted that some of the organisations buy computers before any kind of systems analysis & design has been conducted and they don't know what to do with them later on or use them inefficiently. Eritrea, therefore, should exploit the opportunity offered by information technology. To do so, Eritrea should focus on human resource development, according to the Director's opinion. It should develop networks experts, systems analysts & designers, programmers (particularly application oriented database programming). If this is done, Eritrea could even proceed to enter slowly the international software market using the expertise and experience of the Eritrean Diaspora.

What information technology strategies and policies did EISA produce? None, except some directives in which was given a list of the kind of hardware and software should the Government Departments and Public Enterprises buy (this was done through circulars but never by giving a comprehensive manual of policies, procedures, and rules). It gives also very limited support in systems development and implementation, and limited training to the public sector.

The existing manpower resources and facilities are not adequate for EISA to accomplish the mandate given to it in the Proclamation. The Proclamation No. 53/1994 is not working in practice. There is no clear picture of how this Agency is going to overcome its present problems. For one reason, EISA was established to serve only the Government and the Public Enterprises. It is possible to say that it does not have the mandate to formulate the national information technology policy or plans. On the other hand, there is no other Agency, Ministry, or Commission with this responsibility.

Customs duty and sales tax on computers and accessories are around 17 percent, but importers with their own foreign exchange resources are charged as high as 50 percent. This is because the Customs Office does not accept prices in the invoices of importers but uses its own estimates which can be as high as 150 percent of the real price or even double the original price. The time spent in clearing goods is also an additional cost, which at times can be really damaging to the business of importers. Business people say that recently some improvement have been made but still there is a long way to go to have in place a very efficient system in the various customs offices. One of the frustrations of computer services and suppliers companies is the low level of skill of the people in the customs offices. Particularly the poor knowledge of computer technology and the fast changing product range and prices in the computer industry is beyond their grasp and for any trivial thing they turn to their Head Office to get directions or information on prices. This takes long time and business people get frustrated.

Some of the computer supplying companies were importing computer parts to be assembled and sold in the country because cheaper than importing a finished one. But computer suppliers had to discontinue it because of the Customs Office's existing policies. They were asked to pay a very high custom duties and sales tax, in other words, the tax paid for the different parts of a computer was considerably higher than tax paid for an imported computer. It is lower to pay a tax for a complete computer than for the unassembled parts of the same computer. Of course, the Customs Office does not mean to discourage computer assembly plants in the country but that is what in reality is happening.

Therefore, the country needs very clear information technology policies and all other policies should work in synchrony with it and not militate against it, like what is sometimes happening with customs and tax policies. The people implementing these policies should also be up to the level of their task.

11.4 Institutional capability

The dissemination of IT requires the development of an adequate technical infrastructure. This may include developing institutes for setting standards for the procurement and use of IT, building indigenous IT production capability, developing digital telecommunications services, building computer support services, and building appropriate institutes of research and training.

During the 1940s and 1950s Eritrea had one of the very sophisticated telecommunications services networks in Africa. This was totally destroyed during the protracted war of liberation with the exception of Asmara. By the end of 1998 in Eritrea there were a total of 34,696 telephones of which 25,0OO were found in the capital city of Asmara. This supply is only 50 percent of the demand. This gives us 0.913 (taking 3.8 million population as given by the World Bank) telephones per 100 people (SSA excluding South Africa has a teledensity of 0.5 per 100 inhabitants). But its distribution is concentrated in the mainly in the capital city.

Investment in telecommunications facilities in Eritrea is growing from year to year. There is one government owned telephone operator in the country. After 1991, within the limited resource available for expansion, the Telecommunications Services of Eritrea (TSE) has replaced the old analogue switching systems with the digital switching systems. At present there are one ARFIO2 model (the only old model analogue system left) and ten AX-10 model digital switching systems all supplied by ERICSSON. Two earth satellite stations have being installed, one for the Atlantic Ocean (1993) and the other for the Indian Ocean (1997). Microwave stations have been installed across the Asmara-Ghinda-Massawa line, Asmara-Ira-Elaberet-Keren, and Asmara-Dekemare-Adikey-Senafe. In the near future Asmara-Mendefera-Areza-Barentu and Keren-Afabet-Nakfa will be added. The aim of these investments is to directly link all the major towns in a national and international network. The cities directly connected to the national and international telephone network are Asmara, Massawa, Assab, Dekemhare, Mendefera, and Keren. The rest of the country is linked to an operator room in Asmara through HF, VHF, and UHF radio link.

The telecommunications sector is undergoing profound changes. The government is changing from its former role of telecommunications services provider to that of regulator. The country does not have a master telecommunications plan and as a result there was short-term focused planning and implementation. This is because of lack of funds to undertake major infrastructure changes, limited technical know-how and above all the lack of a regulatory institution. To remedy to this, the Government of Eritrea and the Government of Norway signed an agreement on August 28, 1995 for the provision of financial assistance in the establishment of a telecommunications regulatory institution in Eritrea. Soon afterwards the then Eritrean Post and Telecommunications Authority (today, The Communications Department) has signed in March 1996 a contract with the Norwegian Post and Telecommunications Authority (NPTA) for support and institution building to implement the project. The current budget allocation for the regulatory institution is about NOK 5.5 million of NORAD contribution and for the next 4 years extension, the budget proposal is US$1,970,000 as Norwegian contribution and US$626,000 in local currency as the Government of Eritrea contribution.

Parallel to the regulatory institutional building, the Government of Eritrea is taking the necessary measures to privatise the Telecommunications Services of Eritrea into a joint venture with a South Korean Company, Daewoo. The Memorandum of Understanding was signed on June 17, 1997. Teams from both sides negotiated from July 24, 1997 - August 4, 1997 on the following agreed agenda: 1) Joint venture proposal of Daewoo, 2) regulatory requirements of Communications in Eritrea, 3) regulatory requirements of

Investments in Eritrea, and, 4) needs and requirements of TSE. But the following major issues of differences called for lengthy exchanges and negotiations:

a) Exemptions from taxation privileges and guarantees called by Daewoo's team.
b) Distinction, extent and ascertainment of Daewoo's initial capital contributions in kind and in cash.
c) Casting vote in the Board of Directors meetings reserved and always to Daewoo.
d) Determination of Management and Services Agreement by Daewoo.
e) Exclusivity of supply demanded by Daewoo for all materials and telecommunications equipment and requirements for all company for the duration of the company.
f) Assignment and conduct of feasibility study.
g) -Exclusivity of Management and Services Agreement with Daewoo.
h) Daewoo to formulate and determine telecommunications tariffs.

The Eritrean side made it clear that it can make some concessions with regard to exemptions from taxation for a limited period but rejected the other demands by Daewoo as 'not fair and equitable'. Soon afterwards, the Eritrean side sent a new joint venture proposal and Communications Proclamation of the State of Eritrea on August 22, 1997. Daewoo's team arrived in Asmara to take-up the negotiations again on September 24, 1997. After lengthy and exhaustive discussions on each and every article of the joint venture proposal, an agreement was signed on October 3, 1997. After this agreement the Eritrean team started working on the procedural matters concerning the incorporation of the new company. It was at this stage when, both the financial crisis in Asia and the border wax between Eritrea and Ethiopia, added difficulties to the implementation of the joint venture. It seems destined to abort. Nonetheless, the Eritrean side has accumulated new experience in the skills of negotiation and use it in the future in similar ventures.

The expectation is to expand and modernise the telecommunications infrastructure of the country quickly. The Minister of Transport and Communications, when explaining the objectives of the joint venture, made it clear that all the cities in the country will have a telecommunications infrastructure to directly link them to the national and international telecommunications network by the year 2000. Presumably by the year 2003, the network will reach every corner of the country (Haddas Eritrea, 28 October 1997, p. 1).

Another interesting move recently made by the Government of Eritrea is to enacting the COMMUNICATIONS PROCLAMATION, proclamation No. 102i1998. This proclamation wants to be the basis for the establishment of an open market oriented communications industry. The Ministry of Transport and Communications is the sole government agency vested with the regulatory authority of the communications sector. It will supervise and promote the provision of communications services in Eritrea. It has the authority to issue, renew, revoke or transfer permits, equipment approvals, certificates, assignment of frequency and other regulatory documents in the communications sector on behalf of the Government of Eritrea. The Department of Communications shall be the body empowered to exercise the authority.

The proclamation states the various objectives the Department of Communications should achieve:

1) Create a regulatory environment for the supply of communications networks and services.
2) Promote fail competition and efficient market practice in the communications sector;
3) Facilitate the entry into the markets for communications services of persons wishing to supply such networks and service.
4) Ensure that operators, suppliers and installers meet their commercial obligations and such other obligations specified under this Proclamation in a manner which promotes cooperation and fairness.

5) Protect operator, suppliers and installers and the public from the unfair conduct of other operators, suppliers and installers, regarding quality of services and payment of tariffs:
6) Ensure that operators, suppliers and installers achieve the highest possible level of accountability and responsiveness to customer and community needs;
7) Ensure that standard telecommunications, broadcasting and postal service is supplied as efficiently and economically as possible and at such performance standards which reasonably meet the social, industrial, and commercial needs of the community;
8) Promote the development of the other sectors of the Eritrean economy through the commercial supply of modern communications services within the framework of the Proclamation.
9) Establish technical standards and promote the development of Eritrea's communications industries capability and skills;
10) Ensure that the Eritrean public have growing access to communications; and
11) Optimise the use of communication networks and services in Eritrea with due consideration for the rights of the operators, suppliers and installers and the public interest. (Proclamation No 102, 1998, pp 39-10).

The major functions of the Department of Communications are: regulating the communications industry, ensuring safety and quality of communications services, giving advice and assistance to the industry, promoting competition, and facilitating the entry into the market for communications services by investors.

Since there is always a gap between the good intentions and the actual performance, only time will tell whether the Department of Communications will have performed according to its plan and have established a vibrant and competitive communications industry. If Eritrea is able to establish a good telecommunications infrastructure in short time, the country will have one of the basic ingredients leapfrog into information technology.

The Department of Communications says that 'The State of Eritrea takes the development of the communications services industry not as a separate service giving sector of the economy but as integral component of other social and economic development efforts. The State promotes this sector because it has direct effect on the efficiency of public and private business of the country. Furthermore, the availability of communications services determines how attractive Eritrea is to local and foreign investors. To make this possible, the Department of communications has prepared a telecommunications network development plan. The establishment of a modern and effective telecommunications infrastructure in Eritrea called for:

a) The introduction of a new approach to replace the old policy and regulatory framework that governed and regulated a monopoly provision of communication services. To pave the way for this, a new communication law was proclaimed by the State of Eritrea. This proclamation allows the Eritrean telecommunications industry to pursue a flexible approach to provide modern and high quality services to all customers taking into account the fast technological change in the sector.
b) The search and understanding of trends of the next cycle in the technological change to improve the network, with digital overlays, wireless systems and human resources development.
c) The introduction of telecom and information communications base in the network by introducing radio transmitters operating in various modes and frequencies to enable the customer full mobility. Cellular radios, cordless telephones, radio pagers, pay phones are being introduced. In view of developing telecommunications and TV distribution multipoint radio system is being introduced.

According to the master plan of the Ministry of Transport and Communications, in the coming three years, 1998-2000(phase I), an additional 56,000 telephone lines will be installed which will be followed by another 70,000 lines in the subsequent phase, 2001-2005(phase II).

The required investment in the development of the information and communication infrastructure of the country is given Table 11.9 below.

In addition to the above investment, a US$10 million investment would be required for telephone services in the rural areas. The rural telecommunications services are expected to be implemented in phases. In phase one, the intention is to provide phone services to 55 sub-region capitals that do not have phone services already. In subsequent phase, a total of I300 villages will be served out of a total of 2800 villages in the country. The implementation of this project may take 5 years (ibid. p.82).

Table 11.9: Planned investment for national telecommunications network infrastructure development

Investment (US$ millions)	Phase I (1998-2000)	Phase II (2001-2005)
Subscriber premises equip.	1.9	2.8
Switching and related investments	12.6	20.2
Outside plant	6.2	18.0
Transmission equipment	4.5	19.0
Buildings, vehicles, tools & instruments	3.0	12.0
Total	**28.2**	**72.0**

Source: Communications Department, Final Quarter Report, 1998, pp 79-81.

The national long distance network is planned as a grid system, so that if one system fails or there is traffic overload an alternate route is available, to ensure that there is no disruption of communications. It also aims to connect towns directly to their administrative capital or regional centres. All microwave equipment shall be SDH- STM 1 type except for some spur links which shall be SDH/PDH type. The traffic or the need for broad band on certain routes may in the future justify the use of optical cable systems. This network will be complemented by cellular and other wireless communications systems with the aim of providing these services in large urban centres and along busy highways (ibid. p. 75).

Shore to ship services is planned to be established by HF and VHF shore to ship communications at two important ports of Massawa and Assab on the Red-Sea. National transit switching centres are being established and a switching hierarchy appropriate for the country is being implemented. International (regional) terrestrial links to neighbouring countries shall be extended using the SDH - STM Microwave system. Massawa - Asmara -Kassala (Sudan) will be extended and it is being constructed. The already existing link with Ethiopia via Massawa - Asmara - Dessie is upgraded by installation of SDH - STM system. Direct Massawa - Assab - Djibouti link is soon to be established. International satellite links exist through the earth station in Asmara (BetGhiorghis) and submarine Fibre Optic landing point in Massawa is planned. One Inmarsat station will be established in Asmara or Massawa soon. Data Service Providers are being licensed to operate in Eritrea (ibid. p. 76).

Beyond year 2000, Eritrea expects to be a party to the Africa-One Fibre Optic cable network and it has signed a Memorandum of Understanding with the sponsors of the project. Under consideration is the Oxygen fibre optic cable project expected to be in place between year 2000 and 2004. This will provide a broadband communication for international services. The intention is also to introduce new services such as GMPCS. Internet service and Telemedicine soon (ibid. p. 82).

Eritrea has been left behind in Internet connectivity. According to the Department of Communications, The main reason is because the country did not have the law to govern the communications industry. On March 2,1998 a Proclamation No. 102/1998 Communications Proclamation has been enacted. The Department of Communications has been vested with the power of creating the regulatory environment for the supply of communications networks and services. A person, desiring to establish and/or operate a telecommunications network, and/or to provide a telecommunications service must obtain an operator's permit. The Department shall determine whether any of the activities referred to above are exclusive rights activities or limited competition activities. (Proclamation No. 102/1998, p. 45). Therefore, from now onwards private companies can establish value-added services such as the Internet by getting the license from the Department of Communications. Otherwise technically there should not be any problem.

With regard to e-mail services, there are at least two private computer services companies giving such services. E-mail service is no more a problem for those who want it and do have PC and a modem at home or in their office. At present the country is one of the three African countries without full Internet connectivity. Somalia has none but Congo (Brazzaville) and Eritrea will have one shortly. Eritrea has signed a memorandum of understanding with the USA to co-operate in a mutual effort to establish a national Internet gateway in Eritrea on the 6 of August 1999, (Eritrean Profile, vol. 6, No. 22, August 7, 1999). The project should be completed and ready for public use within the next three months.

In Eritrea now there are more than 30 computer businesses operating mainly from the capital city of Asmara. There is a Compaq dealer, an IBM representative, and H-P dealer. The rest are firms supplying hardware and software from whatever source to satisfy the demand of customers. Eritrean importers are increasingly looking to Dubai and it is becoming the centre of cheap computer products, but the Far East, Europe and USA are also very important sources. But particularly the quality and reliability conscious buyers look to Europe and USA. Besides, these companies give training, and maintenance services. Since all of these companies are established recently, mostly after 1993, they are young with critical shortage of skilled staff.

Electricity supply is very essential for computerisation to take place. In Eritrea electric supply is controlled by Eritrean Electric Authority (EEA), which is an autonomous organisation under the Ministry of Energy & Mines. Reliable electricity supply is available for the capital city of Asmara, the port city of Massawa and the towns across the road of Asmara Massawa (an interconnected system). The other towns have their own electricity power plants, which work independently in a self-contained system. The electricity supply, in these towns, is not fully reliable and does not have a 24-hour electricity supply. Majority of the Eritrean population lives in rural areas, about 70 percent, and they don't have electricity supply. In fact, Eritrea has one of the lowest electricity consumption in the world, about 35 k Wh/year per head in 1995 (Programme Formulation Mission for Sustainable Energy in Eritrea, p. 3).

All the generation stations run by EEA have an aggregate installed capacity around 71 MW, from which around 53 MW is in the interconnected system and nearly 18 MW in the self contained systems. In the Asmara-Massawa interconnected system, electricity is distributed in both 220Y and 127V. All the other self-contained systems in the other towns are 22OV . A new thermal power plant with capacity of 84 MW is being built in Hirgigo, south of Massawa. A 132 KV transmission line from Hirgigo to Asmara will be erected and the self contained systems of Dekemhare, Keren, and Mendefera will be connected to it through 66 KV transmissions. This project is estimated to cost $200 million and expected to be completed in five-year time

(War-Torn Societies Project - Eritrea (Infrastructure), Final National Workshop, Asmara 5-6 December 1996,p.27).

The expectation is that by year 2003 all the major towns will be interconnected in a national network and that the rural areas across the network will be getting access to electricity. By modernising the electricity distribution system, it is expected to improve the reliability of the electricity supply soon. This will be a great help to the diffusion of communications and information technologies in Eritrea.

Government institutions to help the promotion, transfer and diffusion of information technology are almost non-existent. The only institution established under the Office of the President is EISA but it is hardly an institution that can absolve that mandate. Its services are very limited and confined to the civil services. The same institution was supposed to deal with policy issues and co-ordinate policy implementation but no progress has been made in this respect. An assessment of its activity is given below.

1. Policy and co-ordination - It does not mean that EISA is not giving some services to Government Departments. But because the services are so limited and incomplete, they do not really match its original objectives. In the area of policies, what EISA has done, so far, is to give general guidelines and standards for government computer purchases. No manpower development activities are undertaken by EISA except some limited short-term training to government employees in the newly emerging MIS departments of the various government departments (see table 11.10).

Table 11.10: Evaluation of policy and co-ordination of ISA

ACTIVITIES	Accomplished?
Develop and promulgate a set of standards and supporting guideline regarding government and public enterprise sector: • acquisition of computer, and • maintenance of computers	YES NO
Develop an appropriate set of policies and management practices supporting more effective and efficient application and exploitation of information technology within the Government and the public enterprise sector.	NO
Develop and implement technical training programmes within the Government and the public enterprise sector. Develop programmes on improving and encouraging training .delivery capacity within the private sector.	YES NO
Support other Government policies and priorities in the area of information technology such as: • computer accessibility • conversion to national script • regionalisation • private sector industrial development • research and development The development of high priority government and public enterprise sector management information systems (MIS) General manpower development	NO NO NO NO NO YES/NO NO

2. Client Services: In the area of client services, EISA has done some reviews of information systems development proposals made by various government departments, some programming services, and the development of MIS for the Office of the president. With regard to its staff development, EISA has been very slow to action. It has only recently started to send few people abroad for short term training and recruited two fresh graduates from University of Asmara for on the job training (see Table 11.11).

Table 11.11: Evaluation of client services of EISA

ACTIVITIES	Accomplished?
Develop programmes and mechanisms to ensue acceptable quality in the delivery of its services and Products, and to ensure that there is m acceptable degree of client satisfaction	NO
Establish internal EISA human resources training and education of staff in order to ensure that the skills and educational requirements are commensurate with the client demands for services	YES/NO
implement internal technical resource bases and associated managed facilities in order that current and anticipated client demands are met in a cost effective manner	NO

EISA could become a very effective institution in the diffusion of information technology in the country if it could only mature in its institutional capability. Enough resources should be given to achieve the objectives for which it was established. Therefore, it deserves the necessary attention at the top level of the Government.

11.5 Human capital formation

The human resource supply in the IT skills from within the country is insignificant, almost non-existent. Computer training in Eritrea is a new phenomenon of the 1990s. Immediately after liberation, computers started to arrive in the country in significant numbers. In 1991 the only place where some basic computer application training was the University of Asmara. By 1993 few computer commercial schools had emerged. By the end of 1997 there were about 30 private firms operating in computer supply, services and training. But all of training was confined to operations of personal computers. Formal professional training of systems analysts and designers and programmers is non-existent. Even the only university in the country, University of Asmara, has not been able to establish a computer science department so far. The unit was established immediately before the independence but still is a unit within the Department of Mathematics. The best place to start higher computer skill development would be the university for there is no other institution on sight that can do that. Of course, the alternative is to send Eritreans abroad for training, which is expensive.

The commercial computer schools are fast growing and their presence is being felt. They have contributed significantly in the production of computer operators (in the sense of basic computer applications skills), computer hardware maintenance technicians, and some programmers. One of such schools has trained about 2000 computer operators from 1993-1997. Another trained 730 people of which 502 where female trainees, from July 1993-1996. Still another trained 250 in Microsoft Office, 7 in network administration, 8 in programming, 7 in hardware maintenance, 58 in AutoCAD and 25 in accounting systems.

It is estimated that about 2500-3000 computer operators are trained every year in the country from these commercial schools. But hardware technicians trained by these commercial schools could be as few as 40-60 only. This is because the computer services companies themselves, to enter the market of maintenance services, were training few of their students for this job. This was rather a kind of apprenticeship. But few of the computer schools are considering starting a formal training in hardware maintenance leading to a diploma, I or 2-year programme. It is encouraging that some of these computer schools are starting to think regionally to the extent of establishing regionally competitive training institutions.

It was possible to identify within the surveyed organisations 26 systems analysts, 63 programmers, 25 systems managers, 54 hardware technicians, 38 training professionals, and 360 computer operators. Most of the systems analysts and managers are fresh graduates with little experience.24.48% of the respondents think it is impossible to get systems analysts in the country, while 40.56% consider it is difficult, 9.09% not difficult and the remaining 25.87% don't know. A quarter of the respondents don't know may be because they are newcomers to the computer world or they never needed a systems analysts and don't have any experience regarding it. With regard to programmers, 8.39% of the respondents said that it is impossible to find from local labour market, 49.65% said it is difficult, 23.08% said it is not difficult and the rest 18.88% did not know. With regard to hardware technicians 7% said it is impossible, 41.96%o difficult, 22.38% not difficult and the rest 28.67% didn't know. With regard to computer operators 79% said that it is not difficult to find computer operators locally. The majority of the respondents think that getting trainers (in computer applications and some kind of programming) is not difficult (not difficult 53.15%, difficult 14.69% and don't know 31.47%).

To improve computer and communications technology diffusion, Eritrea needs to address quickly the most critical issue: the human resource development in information technology skills. These ranked in order of priority are systems analysts and designers, programmers, hardware maintenance technicians, communications and networks experts, and computer operators. For detail see the Table 11.12 below.

Table 11.12: Priority in critical IT skills development in Eritrea

Professionals	Rank						Total
	1st	2nd	3rd	4th	5th	Don't know	
Systems analysts & designers	56 (39.2)	22 (15.4)	20 (14.0)	27 (18.9)	12 (8.4)	6 (4.2)	143 (100)
Programmers	17 (11.9)	55 (38.5)	26 (18.2)	18 (12.6)	11 (7.7)	16 (11.2)	143 (100)
Hardware technicians	29 (20.3)	30 (21.0)	42 (29.4)	30 (21.0)	6 (4.2)	6 (4.2)	143 (100)
Communication and network experts	14 (9.8)	21 (14.7)	24 (16.8)	37 (25.9)	41 (28.7)	6 (4.2)	143 (100)
Computer operators56	24 (16.8)	12 (8.4)	15 (10.5)	22 (15.4)	63 (44.1)	7 (4.9)	143 (100)

The University of Asmara, as the only higher learning institution, should take the challenge to address the shortage of supply in systems analysts & designers, systems managers, and programmers. The University has a plan to open a new department in computer science.

Given that IT is becoming one of the basic infrastructures necessary to support all the sectors, it should be given priority. Otherwise, the increasing investment the country is making in computing and communications resources may lead to inefficiencies and loss of expected productivity because of lack of skilled manpower that can manage it effectively. But in the mean time this is done, short-term training abroad and within the country should be organised continuously to help organisations cope with the critical shortage of IT professionals and alleviate some of their problems.

11.6 The Melting Pot: IT management and economic development

Eritrea is no different from the rest of the SSA countries. It lacks any coherent IT policy at national level with few exceptions at firm level.

Almost four years ago, EISA was established by proclamation. It was supposed to 'Develop, advise, implement, co-ordinate and promulgate Government information technology strategies, standards, polices and guidelines' (Proclamation 53/1994, p.6). What has been accomplished so far? Honestly speaking, the vision of the Proclamation has been totally forgotten. EISA has not grown as an institution. At best, it is acting as MIS department of the Office of the President with some limited consulting services to requesting ministries and departments, and from time to time, giving training to government employees.

EISA was criticised for giving advice to government departments to buy specific preferred brands such as Compaq at one time. The other suppliers were unhappy about it and complained. Progressively things improved but it is a very important lesson that should never be forgotten in the future to never interfere with the free competition for it may have a damaging long-term effect. It is not to suggest that at a particular time a particular product is not the best value for money. In an industry where change is very fast and continuous, it is very risky to bet for a particular brand. But guidance needs to be given as to desirable features in order to manage properly compatibility and modularity issues. Even these need to be continuously revised to keep them up-to-date.

When we come to the firm level IT strategies and implementation, we find that it is in a very poor shape. In the last six years, the country saw a flow of significant number of microcomputers (PCs) in both the Government and the private sector. Now, there are many government offices with computers. Our estimation is that 70 percent of computer purchases are made by the Government. Mostly these purchases were funded by development donor agencies such as USAID, SIDA, Italian Government, etc. UNDP is assisting the government in the building of the Public Sector management capability through various kinds of studies and partly financing the establishment of the Eritrean Institute of Management (EM) at Embatcalla. Several of theses studies are projects dealing with information systems development in key Government Departments such as the Central Personnel Office and the Business License Office.

The private sector is mainly composed of micro-enterprises. It is possible to say that 99 percent of them can do their job perfectly without a computer, at least for the time being. But there are a number of small companies such as consulting services firms, travel agencies, computer services firms, photo and video services firms, some import export companies, shipping and forwarding firms and the like are increasingly making use of computer technology in their daily operations.

Nearly all of the systems being introduced are used for batch processing. They are mostly found in the civil services, and other private services. The manufacturing sector is lagging behind service industries with few exceptions, like Fred Hoflows lens manufacturing plant which is a high-tech firm with computer based production system. Even large manufacturing companies' use of computers is only confined to office works like inventory control, payroll, accounts, and personnel records. In agri-business industry we are witnessing some radical changes. Recently the drip-irrigation technology has been introduced in few firms. This drip-irrigation system is controlled by a computer system.

National computer networks do not exist. Neither is the country connected to the Internet. But local area networks are emerging slowly within some government departments.

The implementation of information technology projects is suffering from lack of critical IT skills such as systems analysts and designers, systems software and hardware maintenance technicians, communications networks experts, etc. Particularly bigger projects are invariably requiring external consultants for their systems studies. Examples abound of difficulties encountered by organisation in the computerisation process. Bank of Eritrea is trying to computerise its operations since 1993, but the progress it is making is extremely slow. Now it is a year since it got its hardware purchased but the banking software is still not selected and purchased. Recently the local computer network is installed and some information exchange does take place but it cannot be effective till the necessary banking software is introduced. The Commercial Bank of Eritrea is more or less in similar situation. The National Insurance Corporation of Eritrea has introduced a system with the necessary insurance software but the networking part is not yet installed because the corporation is building a new site for its Head Office and it is waiting to install it in the new building.

The experience of the financial institutions shows how difficult it is for organisations in the developing countries like Eritrea, where the computer service industry is at its infancy, to develop their information systems and properly manage them. The most critical factors identified are lack of skilled manpower to man the emerging information systems, lack of sufficient fund, and lack of reliable local computer services support.

In recent years African Governments are more and more looking to information technology to improve the public sector management and some of their social and environmental problems (Hanna and Boyson, 1993). The Government of the State of Eritrea has from the very beginning shown great interest in it. To have a closer look a deeper sector analysis is given below.

11.6.1 Information Technology in the Agricultural Sector

Agriculture production in Eritrea is subject to the rainfall uncertainty and the consequences of having wide annual oscillations in grain harvests pose serious problems to food security throughout the country. The needs for food information in Eritrea relate to the quantification of annual cereal import requirements and the early identification of food crises amongst specific vulnerable groups of the population. Decision-makers make decisions based upon essential information sources, which regard the targeting of beneficiaries and matching types, quantities, timing and duration of relief to actual requirements. Other aspects of food security information include: regular crop forecasts, cross border flows of people, food and livestock, grazing conditions and herd sizes, prices of food and livestock, and other major determinants and indicators of the food security status of vulnerable groups. We will explore this based on the interviews (N. Piccioni, December 8, 1997) and documents from the Ministry of agriculture.

For this purpose, in 1993, the Government of the State of Eritrea established an Early Warning and Food Information Unit. Assistance was initially provided by FAO under the Regional Project GCP/RAF/256/ITA and the national Project TCP/ERI/4451 (Strategy and Terms of Reference for Constructing a Geographic Information System and Database for the NFIS - Eritrea). These projects reviewed the situation with regard to the availability of data and the requirements for technical assistance to the Ministry of Agriculture and other participating agencies.

From December 1996, a comprehensive National Food Information System (NFIS) in Eritrea was established and strengthened under FAO Project GCPS/ERI/0O2/ITA. In June 1997 the MOA/FAO prepared a Strategy Document and Work-Plan to identify the needs and develop the activities of the NFIS Project in Eritrea (ibid.).

In support of this plan, the NFIS is organising a Geographic Information System (GIS) network to co-ordinate food information throughout the country. The programme is intended to develop a National Food Security Information database and network. The formation of a spatially referenced database that is able to index and analyse diverse levels of information (agro-economic, socio-economic and food/relief management) is essential to this effort and will contribute to strengthening national food security by complementing the government's capacity to predict and react to food crises (ibid., p.7).

The database structure of the NFIS consists of a series of specialised sub-databases. The data components are managed by specialised institutions for their own use and mandate and information is also aggregated into the central NFIS database. The specialised sub-databases are (ibid, p. I5):

1. Sub-database on population and administrative structure (NFIS Unit)
2. Sub-database on market prices (Eritrean Grain Board)
3. Sub-database on stocks (Eritrean Grain Board)
4. Sub-database on import/export (Custom Office)
5. Sub-database on rainfall and temperature (Civil Aviation Department)
6. Sub-database on remote imagery (Civil Aviation Department)
7. Sub-database on agriculture production and inputs (Ministry of Agriculture)
    - Sub-database on agriculture production and inputs monthly (Ministry of Agri.)
    - Sub-database on agriculture production and inputs yearly (Ministry of Agri,)
8. Sub-database on nutrition, consumption and vulnerability (Ministry of Health)
9. Sub-database on population movements (Eritrean Relief and Refugees Commission)
10. Sub-database on meteorological data (Water Department).

The central database of NFIS has been established at the MoA's central server. Maintenance of the specific sub-databases are regularly updated by each agency and transmitted to the central NFIS server. This database has been developed in Microsoft Access and after the development stage the system will be transferred to Microsoft Excel formats. The benefits of this set up are that it can accept different formats from the above sub-databases and it can easily retrieve dynamically constructed data from all programme components. Data can be retrieved or keyed in manually. This format is compatible to the functionality of linking the NFIS database to a GIS database; in this case the underlying software is MapInfo Professional 4.1. The export functionality of Excel can replicate formats that are compatible with most standardised GIS software packages and it also can handle data analysis.

The National Food Information System is composed of the national food information system steering committee, the national food information system technical committee, and the national food information system unit.

The NFIS Steering Committee is the formal institution, chaired by the Ministry of Agriculture and Ministry of Health, in rotation, supervising and co-ordinating the overall system. The committee comprises the Heads of various departments/agencies participating for the National Food information System. These are the Ministry of Agriculture or Health, chairperson; General Manager of the Eritrean Grain Board, member; Commissioner of the Eritrean Relief and Refugees Commission, member; Head of the Water Department, member; General Director of the Civil Aviation Department, member; and Head of the Customs Office, member (Ministry of agriculture Early warning and Food Information Unit: Strategy Proposal and Work-Plan, pp. 8,9,10).

This committee's major responsibility is to guide, supervise and disseminate information relevant to food security through periodic Bulletins to be published by the NFIS Unit. It promotes a high profile for the National Food Information System and appoints a NFIS Technical Committee comprising of designated technical officers one from each participating department/agency. It reviews and approves the annual report of NFIS Unit and commission periodic reports on the status of the food information system for submission to higher government authorities as required (ibid.).

The NFIS Technical Committee comprises the focal persons of each Agency and concerned line-Ministries. These are the heads of the Agrometeorological Division of the Civil Aviation Department, Research Department of the Eritrean Grain Board, the Relief Unit of the Eritrean Relief and Refugees Commission, National Food Information system Unit of the Ministry of Agriculture, Nutrition Unit of the Ministry of Health, Hydrometereology of Water Department and Expert of the Statistics Unit of the Customs Office.

The NFIS Unit will report to the NFIS Technical Committee and the NFIS Steering committee as required. It is composed of the Head of the Unit, from the Ministry of Agriculture, and two assistants, also from the Ministry of Agriculture. The NFIS Unit acts as Secretariat to the Committee. The head of the Unit is ex officio member and Secretary to the Steering Committee and the Technical Committee (ibid.).

Sustainability of the system can be seen from the technical and financial aspects. The technical sustainability of the NFIS is promoted through documenting in detail of the methods and procedures developed for the operation of the system, using a modular loose-leaf format to facilitate frequent revision and updating. Appropriate training is provided to the staff of the NFIS Unit and to key staff of other government agencies participating in the system (including staff at regional level), to enhance their ability to effectively implement the methods and procedures developed for the system. The financial sustainability is planned to be achieved by efficient utilisation of resources, budget allocation by the Government and/or sale of information and/or advertising, or sponsors, etc. (ibid. p.12, l3).

This project (GCS/ERI/002/ITA) alone cannot be expected to cover all the areas of development. Its major role will be therefore to define clearly a general framework under which other projects and funds will be channelled to integrate its activities. In this respect, steps have been taken in partnership building under the co-ordination of the National Food Information System, such as the integration of the agriculture Information System component MoA/GTZ; the co-ordination with the ERREC and EGB components of the Canadian Food Grains Bank Project; the co-ordination with the FAO EMPRES programme; the co-development of Socio-economic component with assistance from UNICEF - Eritrea; the Ministry of Agriculture agreement with USAID - Eritrea for allocation personnel to the NFIS Unit; and an agreement with TCP/ERI 6712 (FAO/MoA Support Project to the Development the Forestry and Wildlife Sub-sector) for developing joint GIS training activities.

In due course, there is the possibility of proposing to host, under the umbrella of the NFIS, Famine Early Warning System (FEWS) Unit in Eritrea to integrate the NFIS Unit activities (ibid, p.13).

This experience gained in the MOA is very interesting in many respects. To develop a National Food Information System is forcing a new thinking, that of inter-sector linkages and co-operation. Diffusion of information technology can also happen, to potentially laggard groups as a result of the push made by the early adopters somewhere else because information is required from the first, Therefore, it is possible to use the fervour of the early adopters to pull the potential laggards get involved into projects of information technology diffusion.

11.6.2 Information Technology in the industrial Sector

The industry in Eritrea was established during the 1940s and 50s. Today most of its industrial technology is old and obsolete. Computerisation in the manufacturing sector is non-existent. If there is any computerisation is in the office administration where few computers have started to replace the traditional method of work such as the accounts, stock control, payroll, and personnel records. These are usually the first office operations to get computerised. But there is an exception to all this. The case of Fred Hoflows IOF Laboratory, which is a high-tech manufacturing plant. It can be taken as anecdotal example that it is possible to implement high-tech manufacturing in Eritrea in selected areas. In the next paragraphs we will elaborate this case in more detail.

FRED HOFLOWS IOF LABORATORY was commissioned in 1994 with funding from the Fred Hollows Foundation in Australia, with the express intention of providing developing nations with a source of high quality affordable IOF for use in extra-capsular cataract extraction and lens replacement surgery. The following discussion is the result of interviews (I. Fessehaie and K. Abraha, February 24, 1998) and leaflets published by the firm.

The laboratory was deliberately and purposefully over engineered in order to guarantee the highest quality of manufacturing facility and a finished product that would match world class standards. It was designed specifically for the production of single-piece intra-ocular lenses and other sterile medical devices. The Laboratory was constructed by Eritreans under the direction of engineers and technicians from New Zealand, Australia and Eritrea. The Laboratory commenced with a staff of just four in 1993 and grew to around 20 in 1994 as technical, administrative and construction staff were employed to establish and develop the manufacturing facility. This team took the Laboratory through the IOF validation process and onto full commercial production, which commenced in early 1995. A second shift commenced in April 1996, which took staffing to its current level around 35 people.

The IOF manufacturing equipment has been selected from independent proprietary equipment suppliers according to technical performance specifications cost effectiveness reliability and service and maintenance capabilities of the principal. Quite simply, the Laboratory in Asmara is a world class facility equipped with state-of-the-art production equipment from the USA and Australia. Key production equipment includes two 4-axis CNC air bearing lathes, with 0.2 micron resolution, producing truly equiconvex lenses; a sixteen station CNC air bearing mill capable of producing an infinite number of lens designs and dimensional variations; and a 3M (CFC free) Ethylene oxide steriliser.

Quality is built into the product at every stage of the manufacturing process by an introductory set of over 250 specially written Standard Operating procedures. The Laboratory is equipped with modern Quality Control testing facilities, including its own in-house microbiological testing laboratory. Validation and certification are regularly done. This process includes: routine validation of all critical process steps, internal audit quality assurance, routine external laboratory verification of product quality, at random, and external quality audit by The Fred Hollows Foundation GMP Auditors.

Although the Laboratory production equipment is very versatile, currently it concentrates on the production of one lens design, the FHl06. This is a single-piece PMMA posterior chamber equiconvex (biconvex) lens with modified-C loops and no positioning holes. The lens has been subjected to intensive clinical trials in Nepal, Eritrea and Vietnam and has proven to be a universally acceptable lens. International surgeons have routinely confirmed that FH106 IOLs are of the highest quality and commended the Foundation's choice of lens design and agree it has universal application. (Interview with General Manager and the Production Managers of the Laboratory).

Difficulties encountered during the transfer of this advanced technology were many, but the major ones are the following:

1. Some key machinery from Australia that was installed the first time in 1994 was not to the expected standard. Management complained about it to the suppliers. Experts from Australia came to verify the problem and found it true. An alternative technology was found in the USA and it was replaced with success. To fix this problem took 6-months, i.e. 6-months equivalent of production loss.
2. There was a 10-week production loss because bottleneck-machine (that from America) had a problem. It was not possible to fix it in the country. It was sent to America through DHL for repair. It was a very expensive exercise, about Birr 50,000. After this incidence, the same type of machine was having problems again. It was a real frustration and an unexpected headache to the Laboratory's management. Trial and error methods have temporarily solved the problem but it cannot be the lasting solution to the problem. A lasting solution to the problem would be to give a fully trained technical people capable to repair the machines in case of problems. This is the direction the firm is recently undertaking by sending an engineer for training.
3. High rejection rate (up to 20 percent sometimes) was experienced. It is suspected the quality of wax used in the production process may be the culprit. The procurement function was carried out by an Australian until recently. He left behind him the legacy of buying from a single Australian supplier. Now the Eritreans are in difficulty in discovering new possible alternative suppliers. It is possible to say that a dependency was created and should be broken to move forward.
4. The quality of training received by the Eritreans during the transfer of this new technology was not adequate. The training received in Australia was not a direct hand-on the new technology being transferred but of a general training (three Eritreans for 6-months). The second training, two weeks in America, was not sufficient to enable people to tackle problems but only to operate machines.

Within the manufacturing sector The Fred Hollows IOF Laboratory is the only high-tech operating in the country. There are valuable lessons learned during the past four years of its establishment. It proves that high-tech firms can be established in developing countries such Eritrea but such projects should be carefully planned and the human resource development should be given due attention. Particularly, people should be prepared not only to operate them but also to maintain them without being over-dependent on external expertise.

There is also some experience in a new marble and granite processing plant in Ghinda. The plant is located in a place where there was an old Italian marble processing plant. According to the report made by the managers of the plant, the plant has not been able to produce more than 50 percent of its plant capacity. The problem is the quarrying part of the plant, which is processed in the old manual method. This has created the problem of imbalance between the two processes. The other problem observed is that the blocks of granite or marble that come for processing in the plant are not of good quality and as a result breakage during processing is very high. All of these problems added up together are making it difficult for the new plant to become internationally competitive. The computer systems introduced in this plant are in plant processing control.

These isolated instances of computerised manufacturing systems suffer the most because they cannot get readily from the internal market the services they require. For a sustainable diffusion, it is not enough to import modern machinery in isolation from the whole support system required. Therefore, the technology transfer framework should be carefully studied and the right combination should be selected for every sector as in this case of manufacturing industry.

11.6.3 Information Technology in the Service Sector

This sector accounts for 60 percent of GDP. It is considered to be very critical to Eritrea's economic development. Sub-sectors expected to grow rapidly are wholesale and retail trade, transport, communications, construction, financial services, and tourism services. The computer and communications industry is also an important infrastructure to support all industrial sectors.

1 1.6.3.1 Information Technology in the Financial Institutions

If we look to the financial services, in Eritrea currently there are not many financial institutions. The major organisations are The Bank of Eritrea, the Commercial Bank of Eritrea, the Housing and Commerce Bank, the Development and Investment Bank, and the National Insurance Corporation of Eritrea. Recently, the Housing and Commerce Bank (1994), private bank, and Investment and Development Bank (1998), government bank, were established. A number of private exchange-bureau were established in 1998. In co-operation of the National Insurance Corporation of Eritrea, a number of private insurance agents have been also established in 1998.

Information technology within the financial institutions is at its infancy. Computers are coming but they are still islands of workstations. Integrated banking software is not available. The major three financial institutions are briefly discussed below.

1. Bank of Eritrea (BE)

From what used to be a small branch office of the National Bank of Ethiopia, since 1991 it has become the Bank of Eritrea. It has currently about 80 employees and with the introduction of the new Eritrean currency, November 1997; it is managing on behalf of the Eritrean Government the monetary policies and the national reserves (Proclamation No.93/1997).

Based on the information provided by the management (G. Abraham and K. Tekleab, October 10, 1997), we will discuss the available IT facilities and management at BE. In 1997 the BE has purchased 60 PCs, 31 printers, 6 servers but it does not have a banking software. The total number of computers is 75, including the servers. The computer employee ratio is 1:1.07, which is highest computer density in the country. The project was funded by USAID for the financial aspect and UNOPS in the implementation as a capacity building of the Bank. These are not the first computers in the Bank. The first computers were 3 Compaq PCs brought to the Bank on a lease basis for office automation. Before that there was only a DBS operating system, NCR 990 system, installed in 1986 for General Ledger use.

The new system is supposed to support in all the functions of the Bank: banking functions, administration, research, international fund transfer, money marketing, financial information, etc. Even though the hardware part of the project is all purchased, the banking software is in the process of selection and it looks that it is taking long time. At the time of interview, in October 1991, the managers responsible for the implementation of the computerisation process said that the banking system for internal use would have been completed in a month's time while the selection and purchase of the banking software may take 6-12 months. But till April 1998 things were pretty the same with no progress and change at all. Another thing observed by the researcher was the removal and reinstallation, of the cabling of the internal network of the Bank, because it was not properly done the first time.

The Bank during the systems analysis and design was assisted by an expert from EISA. A private computer company, EWAN Technology Solutions, the representative of Compaq in Eritrea, was the winner of the bid to supply the hardware. It was also the one that had to redo the networking after another small company failed to properly install it the first time. Why EWAN was not given the networking the first time is not clear. It seems that the Bank was trying to reduce its costs by selecting the cheapest bidder regardless of quality and reliability of service. But that decision proved to be wrong when it was discovered that the smaller company was inexperienced and could not deliver the expected quality of service. The Bank had to spend more than it would have paid if EWAN had done the job the first time.

EWAN has the contract of hardware maintenance and computer training of the employees of the Bank. No training was given to employees till April 1998 but the computers are more than 8-months since they were purchased. Usually employees get computer training on their own, in their spare time and their own money. The computers on their desks are not used much for their daily activities, except some word-processing and exchange of information. This is true for all except the accounting section and saving department where simple custom made software written for managing the accounting process and the client saving accounts of the Bank are in operation.

The MIS department of the Bank is just being established. There is only one person (they were two first). He is in charge of the new department. According to him, the greatest challenge facing the Bank is recruiting skilled computer professionals. Some time ago there was a second employee who left the Bank to form his own computer school. He was an experienced programmer who came from Addis Ababa, Ethiopia. The Bank is still working in its account section with the programmes written by this ex-employee. Even now whenever there is problem with the software, he is the one who does the maintenance work. It is amazing how easily the Bank lost that experienced programmer at a time when there is a very critical shortage of skilled professionals. It is clear that retaining skilled professionals is going to be a challenging job. One area of conflict is pay. The pay these professionals get in Government Departments and Agencies is viewed as not competitive in the market. Another flash point is that these professionals want to be treated as professionals with autonomy in their activity without too much interference. At the same time if you employ them without having enough challenging work, they feel unfulfilled and become dissatisfied. In this kind of work environment, they are forced to look for remunerative and challenging jobs with possibilities of development and growth.

Therefore, it is clear that BE is only beginning experiencing information technology, but definitely it is very far away from using this tool as a strategic weapon.

2. Commercial Bank of Eritrea (CBE)

The Commercial Bank of Eritrea is the largest bank in Eritrea. This bank had 6.3 billion of saving out of which 1.6 billion (28-29 percent of the saving) loan was extended (Eritrean Profile, vol. 4 No.48, February 7, 1998). CBE has about 300 employees and 15 branches all over the country. In addition, new branches are being built in Asmara and the rest of the country,

Information has been provided by management of CBE (Y. Ghebremariam and P. Tesfagiofgis, October 74 and 28, 1997) to enable us make basic assessment of IT situation and its management within CBE. When looked from computer facility's point of view, the bank makes limited use of computers. Similar to the Bank of Eritrea, it has not integrated banking software. The first computer was introduced in 1992. It was a 386 PC used to write the in-house developed software. In 1993 ten other PCs arrived which were followed by 25 new PCs at the beginning of 1994. Forty IBM compatible 486 PCs were purchased in 1995 to replace the older computers. By mid October of 1997, CBE had 83 PCs, including seven servers, plus l6 printers, one heavy-duty. Software used is Windows 95, Office 97, Novel 3.72, and DOS Environment. The computer employee ratio is 1:3.6, which is high compared to the average in the sample studied that is 1:12. It is even higher compared to that of the civil services of 1:6.6.

The funding for the 25 PCs purchased in 1994 and 40 PCs of 1995 came from the USAID assistance. These computers are used for current, saving and credit accounts as islands of computer applications. The software used is made in-house. Therefore, they are simple and cannot support a real banking system and perhaps the most difficult stumbling block is the lack of in-house expertise to do that kind of job. The CBE is contemplating to introduce banking software that can support its commercial banking activities. It has plans to phase-by-phase introduce LANs in the Head Office and its branches in and outside Asmara. The WAN will be introduced at a later stage to connect bank branches in different towns of Eritrea (Interview with Yemane Ghebremariam, MIS head of CBE, 14 October 1997).

At present the CBE is making use of two electronic data transfer systems to connect itself with the rest of the world: 1) Western Union, through communication software Money Link, and 2) Saudi-American Bank through Speed Cash.

The CBE used the consulting services of EISA when it was introducing its computer systems. Particularly, one expert from EISA was involved in the development of the in-house software.

The automation plan of CBE was prepared in 1995. The proposed plan was considered to be too expensive because in-house development would require experienced and skilled staff. It was assessed that it would take too much time and money to create a reliable system. The alternative was to buy an integrated banking computer system, an investment estimate of about $500,000 - $ I million. American consultants with the help of USAID were brought at the beginning of 1997 to make needs assessment with the clear mandate to recommend the best way to develop a modern banking system and to introduce an integrated computer banking system. The consultants chose to focus on the Foreign Exchange Department as a pilot study for the computerisation project. if successful, it would be replicated in the other departments and branches. The study's expected completion was by the end of 1997. But now the consultants are gone and the project seems aborted. The reason for aborting the project is not clear but lack of clear vision and lack of funds may be at the heart of such hesitations.

3. National Insurance Corporation of Eritrea (NICE)

NICE's journey towards the computerisation process started in 1992 when the first PC was purchased and placed in the accounts section. The aim was to acquaint and introduce the employees to computers. Parallel to this, employees were encouraged to take basic computer training in computer schools at the expense of the company. The following is based on information from the Finance and Administration manager of NICE (T. Ghebreselassie, October 8, 1997).

Management was seriously looking for less risky and cheaper ways of introducing computers. It considered outside consultants but it was a very expensive exercise. Some Eritreans from the Diaspora when in the country for a short visit or vacation were offering some help in the process of computerisation but nothing could be done in short time with people that offered to help in their free time without charge. Soon management realised that this was not the way to a real computerisation and decided to confront the matter directly by making a contract with an Eritrean computer professional to write custom made accounting software for the company. After four months of work the project was almost complete when the company decided to stop it because it was a single-user system. According to the developer, the original agreement was to develop a single-user system but the company had later on changed its mind and with the excuse that it wanted a multi-user system stopped the project. In the company's view, the project was stopped because the developer could not deliver what was agreed upon, a multi-user system. Anyway, it is clear that the misunderstanding came because the contract was not a clearly written contract.

After this experience, NICE contacted, through African Insurance Organisation, Great Plains Accounting firm that operates in Addis Ababa, Ethiopia. The specifications were prepared by NICE in consultation with EISA. The software of Great Plains Accounting was adapted to the needs of NICE with the help of two experts from the firm who worked for 60 days to install, adapt, and train staff of NICE. Conversion was smoothly done because the two consultants had insurance background and could understand all accounts for insurance activities.

The new system was introduced parallel to the manual system for three months (August-December 1996). The new system results were compared to the manual system results and were satisfactory. In 1997 the company was working on the new system and the old system has been totally discontinued. A year has passed since the new system was introduced and is operating smoothly, according to the Finance & Administration Director of NICE.

- The benefits gained from the new system are:
- it has enabled the company to have up-date financial information such as balance sheet, profit & loss statements, and income statements;
- it has enabled to do performance evaluation such as comparative analysis of budget against actual performance and make variance analysis, compare present against past performances and show the ups and downs of performance.
- it has made possible activity report tracking ;
- accuracy and timeliness of various types of reports have been tremendously improved, e.g. quarterly reports were taking a month to prepare with the old system but now takes only three to four days;
- no more loss of files;
- management time can be more effectively spent on real managerial issues and as a result quality of management is rising.

A system down time as a result of software problem was not observed but because of hardware problems it does occur from time to time. According to Finance & Administration Director of the company, getting hardware maintenance support is not easy because, in general, there is short supply of experienced computer technicians in the country. The company is trying to alleviate that problem by training one of its staff in computer maintenance.

Financial institutions are directed by Board of Directors chaired by the Ministry of Finance and Development. The BE, CBE and NICE are all public enterprises, the legacy of the previous socialist government of Ethiopia. There is always a conflict of interest between each institution's interest and the government's interest. Besides there is always delay to get approval of important decisions, programmes or projects. May be one of the reasons in the delays of computerisation projects is to be found in the quality of leadership at the Board level as well as the top executive level of each financial institution. It is doubtful that among the Board or the top executives, there are people that can act as sponsors to information technology projects with a real understanding that information technology is the future and life of these institutions.

The experience of the financial institutions shows that at the beginning there was a tendency for 'quick fix' as a result insufficient planning was common. For example the situation in BE and CBE seems exactly that. Inadequately designed systems are the cause of delays in the implementation of the system in BE. How could one buy 60 PCs, 31 printers and 6 servers without first deciding what kind of systems software to use? It has to be remembered that this bank is small in size, only about 80 employees. Almost two years now from the start of the new computerisation project and yet the banking software is not selected. The first was in 1993, which was a limited computerisation for payroll and the accounts only. These new computers are mostly idle and it has been a year since they were purchased. In CBE the situation is not much different. The bank introduced some simple islands of computerisation in the saving, credit, and current accounts starting in 1993. But, even though the desire to create an integrated banking system has been there since 1995, so far nothing has been done. What is the problem? It seems that a decisive and strong leadership with a clear vision is missing because projects of integrated banking systems are not operational decisions but strategic. May be the Boards at the very top are not clear about it and have other priorities. One thing is clear, proper systems analysis and design are fragmented and incomplete.

The experience of NICE is relatively better because their focus was on getting good and reliable insurance software, which they got and it seems to be doing well. But in all these financial institutions' experience it clearly results that good IT managers are not available and all the organisations that want to computerise will suffer as a result.

Developing financial institutions of international standard is not possible without introducing, mastering, and adapting information technology. In a developing country's environment, the conventional information technology would be enough to achieve a significant leapfrogging.

The financial sector in Eritrea, as we have already said it earlier, is dominated by government parastatals. The BE, CBE and NICE together make more than 90% of it. Particularly CBE and NICE they are making healthy profits. The majority of the employees in these institutions are at least high school graduates and a large proportion of them have been employed after the 1991 and are younger and easily trainable, if the banks decide to go for major restructuring based on IT. Their customer base is fast expanding because of the expanding business and the Eritrean in Diaspora opening accounts in Eritrea. This particular group of customers is demanding because it has been exposed to services in the developed world. Moreover, the government is encouraging Eritreans from the Diaspora and private investors to use Eritrean banks to open accounts in foreign currencies and it does not want them to be disgruntled because of poor quality of services. There is also a prospect of tough competition from more experienced foreign banks that may soon join the industry because the government is on the path of deregulation. Therefore, these financial institutions should grow and acquire the necessary skills and facilities as regional banking players and be prepared to match competition in an open market. They should work together to develop a framework to guide systematically the introduction of effective computer systems and be able to leapfrog from the present traditional, time consuming and inefficient financial services. This would sign the beginning of the formation of a financial services system of international standard.

Money for the project could partly come from international agencies such as the World Bank and partly from the institutions' resources. Consultants could be used to advice to the appropriate banking software and IT infrastructure system to buy. The company that supplies the technology would be responsible for the installation, testing and training of employees with guaranteed post-installation services till the time local expertise is able to take over. After all, there are well-tested banking software systems already available that can be adapted to the particular needs of the said institutions. This amounts to make a big strategic jump toward future, which is a worthwhile risk.

Earlier we had said that the financial sector in Eritrea is monopolised by the public sector, i.e. almost all of the banking and insurance activities are in the hand of the government, which is a legacy of the Ethiopian government. The only exception is the Housing & Commerce Bank, which is owned by the PFDJ (the ruling party in Eritrea) and private partners. In recent legislation, Proclamations No. 93/1997, Bank of Eritrea Proclamation and Proclamation No.94/1997, Financial Institutions Proclamation, deregulation of financial institutions has been established. This means private investors are allowed to invest in the financial sector. Hopefully this action will increase competition and will attract foreign banks to the region. These banks, definitely come with IT know-how and the local banks would be forced to invest in IT to meet competition, There is a possibility of building a strong financial sector.

The objective of making Eritrea a financial centre of the region is a huge challenge. First of all, one needs financial institutions of international standards. To achieve this, first, the Bank of Eritrea should be able to give quality leadership in creating and regulating the environment for financial institutions. Second, private financial institutions should grow in number and in size and develop the capacity to compete regionally. But at present in the region the countries have not opened up to foreign financial institutions. Therefore, financial institutions in each country are confined to their own national boundaries and the formation of real regional banks or insurance companies will take time to be realised. But the wind of regionalisation and globalisation is pushing hard that changes are inevitable in the near future. Eritrea should build up its financial sector without wasting time. The implication of this is developing highly skilled manpower capable to manage and operate computerised financial institutions, and create regional and international financial connections and partnerships.

The present state of IT in the financial institutions is at its infancy. There is no a real IT infrastructure. The BE, CBE, and NICE have been studied but with exception of the latter which has introduced an insurance software, the other two have yet to select and introduce banking software. It is taking unduly long time to make banking software selection, giving that the process of computerisation did start in 1993-94. The major problem is indecision, fear of risk, and lack of highly skilled manpower. Funding was possible with the help of international agencies such as the Word Bank, USAID and other international agencies, which are already doing much in similar projects in developing countries. Nonetheless, these cannot be excuses for not identifying the stumbling blocks in time and taking appropriate measures to solve them. For example, by now their systems analysis & design should be completed and the implementation would have been in an advanced stage. There is already standard banking software and there is no need to reinvent the wheel. Training of manpower could take place parallel to the systems study. Anyway, IT infrastructure does not mature overnight. Of course, ability to identify and prepare good projects in itself is an art. Having capable people to do it is a great asset. In fact, even preparing projects to get international funding can take considerable time without the experience in developing countries such as Eritrea.

Some external commentators have said that the banking system in Eritrea is outdated and that the transformation of the sole commercial bank into an international standard bank with computerised operations and fast and easy international links is showing little progress (Economic/Commercial U.S. Mission to Eritrea, March 24, 1998). It is true. On the other hand, there are a host of other variables that need be taken into consideration to establish financial institutions of international standard beside IT capability. The absence of competitors in the Eritrean Financial market, and the inability of foreign banks and financial institutions to establish the creditworthiness of Eritrean banks could be cited as some of the causes why foreign firms are not prepared to allow the opening of credit lines for Eritrean businesses. At the same time, the banking system in Eritrea is not yet capable of accommodating their needs. Presently all international purchases are conducted through irrevocable letters of credit. But it is also understandable the extra caution that Eritrea is making in opening its financial market slowly and only to private banks run by qualified and professional bankers to avoid any possible future financial crisis. The Sign that Eritrean financial sector is opening up selectively to competition is clear but it should not take more time than necessary. It may be a good opportunity to become a competitive force in the region by being among the first movers.

The joint Eritrean Libyan bank as a joint investment company between governments may become the first entrant after the financial institution proclamation of 1997. The Eritrean financial market is a small market at present but it can grow. Particularly if we think of remittances of the large number of Eritreans who live abroad and the tourism potential of the country. Besides the open market economic policy and the attractive investment policies of the country, are all factors that can change the face of the country. If quickly the basic infrastructures are put in place including appropriate institutional, legal and regulatory framework and mechanism, more and more investors inevitably will come to exploit the strategic location of the country. Therefore, there is a long-term possibility the country to become a trading and services centre in the region. But it should not waste time to build on the available opportunities for other regional players could snatch them. The most critical factors in developing a financial centre are appropriate IT infrastructure and highly skilled manpower in banking skills, financial skills, commercial skills, marketing skills, business skills, and IT skills are all very crucial for the development of a financial sector. The human resource development plan of the country should specifically address how to make these skills available to this sector. But All of these should be carefully designed to integrate the IT skills to every other skill.

Now, what should BE, CBE and NICE do in order to play a leading role in the application of IT for financial institutions in the country? First, this being a strategic decision, they must, if possible, together commission systems study for modern- computerised banking system in Eritrea and prepare the terms of reference. Next, they could identify a company with the technology and experience in II for banking and make a contract for the systems study to identify the right IT for the Eritrean environment and its needs. Finally, a careful implementation of the project supervised by a joint committee should complete the transfer of the technology. The cost would be shared by all. This is implying a high degree of cooperation among the financial institutions, but the existing relationships are not strong and each is working alone. Therefore, a new ground must be broken. The distance must be shortened and a new culture of networking and closer relationships should be developed. For example, besides the above mentioned joint venture in IT transfer, they can jointly establish a banking training institute or periodically organise together short term training pertinent to the needs of financial institutions. There are also possibilities of conducting, jointly, research activities in the financial sector.

Given that the services sector in general and the financial sector in particular is information intensive activity one expects a prominent place for it in the service industry. But the reality in Eritrea, at least at present, seems to be different. The experience of the financial sector in IT is limited and is not advanced compared to other sectors. There is no spin-off and spill over effect from the financial sector to the other sectors. May be this could be explained by the fact that the country was closed to new technologies because of the war of liberation and already the awareness of computer technology in the continent of Africa was high at the beginning of the 1990s. When finally the country got liberated in 1991, the PCs started to invade all government and private offices at the same time. The arrival of Eritreans from the Diaspora with computer skills gave impetus to the establishment of a number of computer schools and computer service businesses since 1993. The Government restructuring that took place in 1995 also did emphasise the idea of 'lean and efficient' civil services based on computer technology. All of this increased the public awareness of computer technology and as a result there is a big demand of computers in all government departments and agencies as well as public enterprises. Therefore, the financial sector, usually at the forefront of computerisation elsewhere, in Eritrea is starting together with all the rest to embark towards the process of computerisation, which in the context of Eritrean situation means mainly the standalone workstations. But this understanding is proving to be costly in that automating only the existing manual system does not improve productivity. Many of these workstations are not effectively used because they are turned into substitutes of typewriters. May be only 10 percent of their capabilities are used. This should not be allowed to continue and the financial sector should play a leading role in demonstrating in the use of IT as a competitive weapon.

The country needs to identify some sectors, those considered to be the most critical to the economic and social development of the country, and a real IT infrastructure that can lead to a real competitive advantage should be developed. The financial sector is one of these critical sectors and IT should be considered a strategic area of focus.

The Eritrean government should take a proactive strategy to IT like is doing in the transport infrastructure development. Therefore, it should not look passively or allow IT development in a fragmented way of small pieces here and there, which may create compatibility problems later on and frustrate the national connectivity in the future. For example, investing in the development of highly skilled manpower in IT could lay the ground for the effective use of IT as an infrastructure in every sector. Later on, it could lead to the development of software industry for export purposes, like many developing countries are doing because of the competitive advantage of lower labour cost.

11.6.3.2 Information Technology in the Construction industry

The construction industry in Eritrea is growing fast because of the opportunity created by the end of the long war of liberation. The country is facing the huge task of reconstruction, One big company is Keangnam Enterprises, a South Korean construction company. This is involved in big construction projects such as the one built near the international airport of Asmara, the Sembel Housing project ($70m);, Massawa Housing Complex ($60m), Tokar Dam project ($47m);, and the Hirgigo power plant ($114m). There are a number of construction companies (four Italian, five Chinese, and one American) busy building residential housing, public offices, roads, and dams (African Business, April 1998, p.22). To support the construction industry, a number of engineering consulting firms have emerged. Particularly the design stage of any construction project is being supported by computer technology. Whether it is within the Ministry of Public Works or in private engineering consulting firms, CAD systems are being introduced.

Interesting development is going on within the construction industry. The Government and private construction companies have joined hands in the building of the national road network. The private companies are all Eritrean companies. They are working on the Ingerne-Tessenei road (190 Kms) construction project. The firms involved in the project, besides that of Ministry of Public Works, are Segen Construction Company, Gedem Construction Company, and Asbeco Company. If the project is successful, it will mark the beginning of a new era in the country where both the government and private firms work together complementing each other, particularly in big construction works and reconstruction all to be made with internal resources. This kind of joint venture requires higher degree of coordination where the computer information systems would contribute a lot. Engineers could benefit a lot if they could be joined by a computer network to support the design and implementation of projects.

11.6.3.3 Information Technology in the Distribution industry

The wholesale/retail industry is mainly composed of small family businesses. These firms are the least to need computers for their efficiency and as such no computers are seen in this industry. There are neither department stores nor supermarkets in the country at present. Very few big wholesale businesses and import-export firms are introducing computers for inventory control.

11.6.3.4 Information Technology in the Transport industry

The transport industry is growing but computerisation is unlikely to grow because computer use is limited to few bigger transport companies for office activities only. The majority of the companies are buses or tracks operated by individual owners. They rightly cannot see the wisdom of investing on computers to raise their productivity.

11.6.3.5 Information Technology in the Tourism industry

The country has over one thousand kilometres long of coastal line, about 360 islands, cultural and ethnic diversity, different land features, favourable climate and hospitable people. All of these together make up a huge potential for tourist attractions. In 1997 there were about 400,000 tourists in the country, mostly Eritreans living in Diaspora. But the facilities are poor. There are 1700 hotel rooms and 1500 pensions in the country (Eritrean Profile, November 15, 1997). To develop an internationally competitive tourist industry an adequate information technology infrastructure is required side by side with the building of new hotels of international standard across the country.

Currently computers are found in travel agencies, which are linked to the international travel system. The few big hotels are starting to introduce computers which are mainly workstations for office automation. No computer network does exist to facilitate the bookings and reservations. This is mainly because the country is not connected to Internet.

1 1.6.3.6 Computer industry

At present in Eritrea there are more than 30 private computer businesses such as computer suppliers, computer repair services, and computer training. The well established of these are not more than 15. In this research we have interviewed 12 of them: Alem Computer Centre, BIT Computer School, IBM Tesat, Ewan Technology Solutions, Tfanus, CTS, K. M, Computers, Ericom 2000, Sewit International, ETSS, Asmara Computer Centre, and ICET. The insight we got is based on these interviews with their respective managers.

Depending on the background of their respective owner/managers they position themselves in various ways. Some are mainly focusing in maintenance contract services with some limited training services; others, vice versa, focus on training with limited maintenance services; and still others focus on training with limited programming services. The dealers and representatives of well known brand names: IBM Tesat (IBM), EWAN Technology Solutions (Compaq), and Tfanus (HP) focus on computer sales and customer services which usually includes some training and maintenance services. EWAN and Tfanus give also e-mail services. EWAN wants to distinguish itself in telecommunications installation services as well. Very few are exclusively in training.

Recently, text-writing and small kind of desktop publishing services are being given. Four of these organisations want to be in Internet services as well. All of this proves that the market is very fluid and as a result these companies seem to be chasing demand wherever it is. Of course, there is loss of focus but for the time being, in a small market, it seems a wise decision.

Systems analysis and design consulting services are virtually absent. Few of the firms could be able to give the basic consulting services in some systems analysis and design but the customers seem to be biased toward the foreign firms because the local computer business firms are perceived as beginners without the necessary skills and experience. The production of such higher skills in systems analysis, systems design, and in various programming languages is also absent. The University of Asmara is planning to open a new Computer Science Department soon to help in filling the gap.

There is a very interesting development in Eritrea, though, the Eritreans from the Diaspora are slowly coming to the country with new skills and expertise and establishing their own companies. Most of the computer companies have being established by such people. For example, from the 12 computer companies with which an in-depth interview was conducted, 2 are from Ethiopia, 1 from Kuwait, I from Saudi Arabia, 1 Canada, the 7 remaining are from the USA. If the same trend continues in the future, it is possible to have consulting firms for systems analysis and design established soon or the same present computer companies grow to give such services.

Networking in Eritrea is only beginning. There are several networking initiatives such as: AdaINet, EISA, ETE, and HealthNet. AdalNet is run by Beshir Computec and is a Fido node supported by PADIS-net in Addis Ababa which was operational since 1994. The connection is often unreliable because of bad telephone switching between the two countries (currently totally disconnected because of the border conflict). EISA is trying to come up with a master plan to build a Wide Area Network among various government institutions. The ultimate goal of the master plan is to develop a local network that can be linked to a full TCP/IP connection. The Eritrean Technical Exchange (BTE) is currently the major service provider in e-mail services. ETE is running a UUCP link. Linux PC servers are installed at the Department of Energy and University of Asmara to handle the network traffic. ETE connects 3-7 times a day to San Francisco in the United States. ETE connects over 35 institutions in Eritrea and has developed a user base that can nearly sustain full connectivity, if and when allowed. ETE is also the administrator for the ER domain and provides domain name services in the country. ETE is a non-profit project of the international collaborative for Science, Education and Environment, and accepts donations to support its network development activities in Eritrea. Two private computer businesses, EWAN Technology Solutions and TFanus, are also connected to this network for e-mail service giving (ETE, 1996, 1998). Even though, Health-Net has been established in 1994 it did not expand to connect health institutions and health professionals to the electronic mail. Eritrea does not have full Internet connectivity.

Many people are asking what policy on Internet the government of Eritrea has. Some Government officials seem unconvinced about the merits of Internet because they see it as a tool only for the urban elite. But others think it is very important for the government, researchers, traders to get information on markets, industrialists for technology transfer, but the demand side of the equations is believed to be too small to make an investment profitable at this time. The signals given were mixed until the recent signing of memorandum of understanding with the USA on 6 August 1999. This has ended all the speculations and a decision has finally been made to go for Internet, which hopefully will allow Eritrea to be connected to the rest of the world by the end of the year.

In an increasingly knowledge-based economy, information is becoming at least as important as land and capital. In the future, the distinction between developed and non-developed countries will be joined by distinctions between fast developing countries and slow countries, networked nations and isolated ones. The information revolution offers Africa a dramatic opportunity to leapfrog into the future, breaking out decades of stagnation or decline. The real challenge in Eritrea is not technical or financial, but organisational and political. There are many barriers in the sphere of obsolete or non-existent regulatory frameworks that result in constricting barriers to information access and knowledge expansion. Catching-up the wave of IT revolution will require visionary leadership in the country.

To implement a full Internet node would not take more than $250,000-$500,000, with annual operating costs on the order of $ 130,000, exclusive of labour costs. Alternative costs given by the World Bank (1995):

1. Internet node with local server: this option can provide all Internet (e-mail, Telnet, FTP, Usenet) through a local Internet node. Connectivity to a remote Internet node will be provided through a Very Small Aperture Terminal (VSAT, or small satellite earth station). Major advantages that this option will provide are development of local services, and local node administration. The price for this option is $250,000-$500,000 per country, depending on the level of technical support and training to be provided. Monthly operational costs due expected to be around $ 11,000.
2. Internet node without local server: this option can provide all Internet services (e-mail, Telnet, FTP, Usenet) through a remote Internet node. Connectivity between a local service node to be the remote Internet node will be provided through a VSAT. Major disadvantages of this option are remote node administration, slow new user connect, and slower response. The price for this option is $180,000-$350,000 per country, depending on the level of technical support and training to be provided. Monthly operational costs are expected to be around $ 11,000.
3. Virtual Internet node: this option can provide only Internet e-mail service through scheduled mail exchanges, Connectivity to a remote Internet node will be through a dialup TCO/IP link. The major disadvantages are only basic e-mail service is provided, remote node administration, slow new user connect, and no local support. Price range for this option is $65,000-$135,000 per country depending on the level of technical support and training to be provided. Monthly operational costs are expected to be around $7,000.

The International Agencies like the World Bank, WHO/AFRO, USAID, NASA, UNDP, UNICEF, UNFPA are willing to help Africans to build their National Information Infrastructure (NII). Connectivity to the Global Information Infrastructure (GII) seems much easier now than ever before. There is a possibility to move rapidly into the information age, there is no reason why Eritrea shouldn't exploit this opportunity properly. Already what is being done in the computerisation of the civil services in the country is almost exclusively funded by the above mentioned International Agencies. Therefore, it is clearly evident that in Eritrea the barrier to Internet connectivity was not a technical or financial issue but only political and organisational issue. On the other hand Internet is an inevitable phenomenon, there is no political or organisational force that can prevent it for long to happen. The inevitable seem to be happening in Eritrea now for very recently its government has decided to move ahead with the development of Internet (Eritrean Profile, vol. 6, No. 13, June 5, 1999).

ETE was studying how to convert the current e-mail system into an Internet system connection (ETE, 1998). One of the aims of this was to make it a good investment to make money for the country, without subsidy so that it is sustainable. The other is to make it accessible to almost any Eritrean with access to a computer and a modem no matter what their economic level. Finally, it was to make it an optimal balance between price and performance for the average user delivering reasonably good service at a low price if possible. This idea of ETE should be considered for it may come with a new innovative and cheaper way of connecting the country to the world. ETE believes that e-mail user base has almost expanded to the point where it could financially sustain full TCP/IP connectivity, if and when a continuous international connection is permitted. Now that the government of Eritrea has decided to move ahead with Internet development that should not be a problem.

When we think of Internet development in Eritrea, we cannot help it from thinking of the skill and experience acquired by the Eritreans in Diaspora. They have been able to build and run hundreds of websites to serve the one million or so of Eritreans scattered all over the world. Dehai Eritrea Online, Asmarino, Eritrea.net, and Visafric are the best Eritrean wire networks we find in the Internet. These networks have been used for news and debates of various political and economic issues of the country. They have been used to develop the social and cultural activities of Eritrean in Diaspora. All these accumulated knowledge can be easily transferred to Eritrea now that the country is going to have the Internet. We have already seen that most of the computer businesses in the country are established by Eritrean coming back from abroad. They have their network with the Eritrean community in Diaspora, therefore, they can jointly establish Internet services to exploit the new business in the country.

11.6.3.7 Information Technology in Other services

Public utilities such as the electric, water and telecommunications services suppliers are also a growing user-group of computer systems. In Eritrea the supply of electricity is in the hand of the EEA which is under the Ministry of Energy and Mines as an autonomous entity. The TSE is under the Ministry of Transport and Communications. The water supply service is under the municipality. Therefore, they are not private companies. In the last six years, these public utilities service givers have been struggling to computerise their billing systems.

The EEA has embarked boldly on the computerisation process (Interviews, A. Woldeghebriel, H. Tesfagiorgis, and T. Gebreab, October 27 and 29, 1997). The only minicomputer in the country, an AS/400 with 10 display stations and two printers was introduced to improve the manually long and boring process of billing, in 1994, Some thinking is going on to use the full capacity of the AS/400 by creating a network that could serve, besides the billing section at the Head Office at Asmara, the inventory management, accounting and payroll, and the sales division (consumers division) in Asmara and in the other towns. A CAD system is being introduced in the engineering workshop and three engineers were under training under two Swedish consultants. The distributed network system is increasingly becoming relevant to solve some basic problems of billing and collections. The company needs to do more with regard to systems analysis and design before venturing into any haphazard introduction of new computer systems that can drain the meagre resources of the company without gain in efficiency. The power production plant of Beleza uses computer production control in the newly commissioned plants. The Hirgigo project, under construction, also will have installed computers for production process control.

The experience of TSE and its computer systems goes back before the independence of the country in 1983 (Interview, A. Ghebregiorgis, October 16, 1997). At that time TSE was a branch of the Ethiopian

Telecommunications Services (ETS). In 1983 ETS Head Office at Addis Ababa had introduced Systems 3400 to computerise its billing processing and Asmara branch was linked to it through the microwave and a dump terminal and a printer. This worked till the 1990 after which things went back to the old manual bill processing system. Computer processed billing system was slowly reintroduced in 1992. Various attempts followed to constantly upgrade the billing system till 1996 when 15 PCs and a server arrived to change it to a more acceptable level. The total number of 23 computers in all of the TSE paradoxically makes it one of low density because the computer employee ratio is very low, 1:27.3 excluding the contractual workers. The joint venture being planned with Daewoo may change this company beyond recognition in the near future, if it goes to port.

Similar to the previous two, the Water Supply Department of Asmara Municipality has introduced the computer processed billing system in 1997. In the other departments things seem to go in the old manual system. The major problem is lack of necessary funds, of course.

Various consulting firms have emerged particularly after 1993. These are also among the heavy users of computers. When we come to maintenance services, computer maintenance is emerging as very important and fast growing business area.

Publishing is also another growing business, which is increasingly looking for computer technology to reduce cost and increase productivity. A good example of this is Sabur Printing Services, a joint venture between the PFDJ (Popular Front for Democracy and Justice) and Eritreans in the Diaspora. Its production capacity will be more than ten folds from the present capacity with the latest technology of over $20m worth of fully computerised equipment (African Business April 1998, p. 24). It is expected to be fully operational in 1999. From the small private printing presses, Francescana Printing Press has introduced computer technology first.

11.6.4 Information technology in Government Civil Services

We have already said that the government civil service is the biggest computer purchaser in the country. There are some Departments and Agencies that have made relatively considerable progress in the process of computerisation and the demand for more computers and networks is increasing by day. The main problems are the necessary funds and skilled manpower. Below I will attempt to give some of the experiences of the major cases.

The Ministry of Local Government is trying to build a local network to link all the various sections in the head Office (Interview, T. Tekle, 22 October, 1997). There are 33 PCs with 12 printers. The MIS section was first established 1n 1994 with four people. In 1996 with help of a consultant from a local computer business firm, CTS, the LAN has been built and staff trained to use it. Currently through the LAN people can share the server and printers but to exploit fully the capacity of the LAN, all existing manual records and files need be changed into a digital form that can be directly accessed by the computer. The Head Office is already connected to two remote areas, Massawa and Mendefera through a modem for direct file transfer purposes. Soon others will follow. This experimenting with LAN and WAN will prove to be very valuable in the near future because the know-how is slowly building up and it will become an asset to the Ministry. The training to the staff took 342 hours mainly spent in learning the network administration, access and visual basic, and MTX. The support and maintenance services continue with CTS (Computer Technology services) and it seems a good work relationship has emerged.

The Ministry of Trade & Industry started to seriously look into the computerisation process in 1995 (Interviews, T. Woldeyohannes and B. Tesfay, October 23, 1997). During that year, an evaluation was made of the existing situation of computing which consisted only of l2 PCs, and a thorough study or a complete systems analysis and design was recommended. Particularly the networked computing environment was considered to be the best option for the Ministry to leapfrog in the use of information technology. Going from LANs to WANs could be easier later on, particularly getting connected to the world through Internet. This could easily enable Eritrea to interact and communicate with COMESA and other regional and international organisations and other international markets. One very critical factor noted in the evaluation was the lack of computer skills among the employees of the Ministry. Based on the recommendation, computer literacy training was given to employees of the ministry and the systems study was conducted by two young systems analysts of the Ministry. The study was completed by mid 1997 and was submitted for review and approval to EISA. The reply from EISA was long to come but by the beginning of 1998 the 'no objection' reply finally came. The plan is to implement the project phase by phase. The project was estimated to cost US$360,000, including 10% of contingency costs. Getting the money and skilled people are going to be the most critical factors to the success of the project. In fact, by mid of 1998 already the two young promising analysts/programmers had left the Ministry to pursue their own careers abroad. The continuity of the project may be at risk now. This may be a signal of a serious brain drain problem in the country.

Business License Office (BLO) experience is unique. The office was created from scratch (Interview, T. Berhane, November 10, 1997). Getting a business license was a very bureaucratic and long process going from one office of a ministry to another that took from a minimum of one week to four months sometimes. The Government was determined to cut all the time and the back and forth among different offices to a one stop service in the shortest time possible. This was necessary to attract potential investors. The new organisation (established by Proclamation) and computer system (12 computers in all) of the Office has enabled to achieve the sought objectives and now getting license is only a matter of 30 minutes. How was this possible? The job establishing the BLO was given to one of the task force members involved in the study of Government restructuring and license system, This person had worked with IBM (Ethiopia) in 1972 as systems analyst and he was the one to design the new licensing system, which was approved by the Government. The same person was appointed as Director of the new BLO with the responsibility to implement the project. Eighteen months of hard work with the help of the EISA Director to write a programme for the system and funding of computer purchases from the UNDP, the new system could start to work. The fact that to write the programme took only three months but to debug it took almost a year is by itself is revealing the amount of stress through which the developers passed. The Director of the Macro Policy Office (Berhane Abrehe) did play the role of the sponsor at the top Governmental level during the entire process. The BLO director says that the involvement of people in the project early on helped a lot. When they were first recruited, the director himself gave them training on communication skills, work organisation and effectiveness, time management and computer systems for six months. For a year, a two-hour meeting every Saturday to discuss problems encountered by employees has enabled to develop trust and co-operation. The project is considered a success. This office was first established in 1995 and already it was looking for better hardware/software to upgrade the system in May-June 1998. A contract has been made with a consulting firm from Canada to upgrade the system. The first system worked on database programme written on Clipper 5.2 and Novell 3.12 for the network. While the new system is expected to work in an Oracle environment and the eight branch offices will be connected to form a network. A consultant came to Eritrea to work on the project in June and did some work but was not to the satisfaction of the organisation and as a result the project has taken more time than expected.

Education is lagging behind in the use of computers. Lately, in 1998, some attempts to introduce computing at the high school level were being made by the Ministry of Education. Few high schools in Asmara have been targeted as experiment ground. It will take time before we could see computer labs in Eritrean high schools become a reality. Of course, the problem is mainly lack of funds and skilled teachers in computing.

The University of Asmara is of course an exception where there is a relatively large concentration of computers, about 200 computers, all PCs. There is the e-mail service at the university but local networking process has only started. But there is a phased plan to computerise and network all departments of the university. The administrative wing of the university, with the help of Dutch Government funding, has prepared a plan of computerisation of its accounts, personnel, inventory management and students records. The plan has been prepared with help of Dutch experts from Groningen and Delft University of Technology. As a ground for training purposes, a small network has been installed in 1996-97 (Information Technology plan University of Asmara: planning Information Technology modules 1997-2001, 1997). Now an IT-platform is in the process of formation, which will enable access to administrative software. For this purpose two new software packages have been selected recently: ARIS (Academic Register Information System) for student administration and SCALA for financial administration. ARIS and SCALA require Windows-NT. Now a terminal emulation package will be used to enable the Windows 3.11 desktops available at UoA to approach the NT system to minimise costs. The system is expected to be ready by July 1999 (Memo, Final Project Plan ARISAIT Asmara, December 22, 1998).

The Ministry of Health has three big Departments; I) the Department of General Services under which are the hospitals and primaries; 2) the Department of Pharmacy; and 3) the Department of Human Resource Development, Information Systems & Research. In the central health information processing, there are 7 Pentium PCs with 4 printers (1 laser and 3 ink-jet); in the six health zones, there are one PC and a dot matrix printer each. Other 23 PCs are distributed to the rest of the ministry offices. Under the Health Information Systems Unit there is the Heath-Net. Thanks to the work of an Eritrean who lives in U.S.A. to create a Heath-Net was possible. This Eritrean took the initiative of asking for help to make free access to the Health-Net possible for Ministry of Health in Eritrea. This system connects the MoH directly to the Health-Net services in the U.S.A. via a satellite communication system. It started in 1994. But there are only about 15 access points in the Ministry of Health (Interview, Dr. Berhana Haile, November 26, 1997).

In the future, Health Information Systems Unit has two major objectives to accomplish: 1) to make information available for decision makers timely and accurately, 2) to make information available to national and international users. At present no linkages exist with others outside the MoH. But in the future there is a plan to develop a community based health information system, therefore, a linkage with the Ministry of Local Government and the Ministry of Labour & Social Welfare will be necessary. MoH has maintenance service contract with Gelatly Hanky Company. Therefore, it has no intention to have own maintenance unit.

In the Ministry of Health there has always been the practice of record keeping. But it was not designed to support decision-making. It was time to have one. First a consultant from the UK made a systems study in 1995. Since that was limited in scope, a new systems study started in August 1996 with a consultant from the U.S.A. and USAID as the agency funding the project. The consultant has worked for 12 months. The systems analysis and design is completed. Now the implementation phase has started. It was expected the project to undergo the testing period during the first quarter of 1998 to be fully operational by the middle of the year. One of the major difficulties was that the consultant left for America after 12 months of working in the country. He continued to work on the project from there. But originally the idea was for the local staff to learn from the expertise of the consultant on the process of systems analysis and design. Another difficulty is that some of the senior people in the MoH found it very difficult to understand that such a system as envisaged by the project would ever be possible in the country. They were sceptical and less supportive. Therefore, selling the idea to them was very difficult. The next difficulty, of course, is expected to be funding. The project will be funded by the USAID till 1999. After that, what will happen to it? Hopefully, the Ministry will look to it and allocate the necessary budget to sustain and develop it.

With regard to human resource development, MoH so far has trained one of its staff in the U.S.A. for a year in computer systems who now is back. The same person did also a three months training in dBase programming in Eden Computer School in Asmara. Another has been trained in systems networking for three months in Asmara. The plan, for 1998, is to train more people. One will be sent abroad to learn programming and two other people will undergo short course training in data management within the country. This team of five people should constitute the IT professionals to manage and operate the information systems of the MoH.

The National Statistics Office is only emerging now. It is a new institution. Its computerisation process has been very slow. It is working with 4 senior and 8 junior statisticians, 2 programmers and 8 computer operators, and other 18 office workers. Their first computers were installed in 1994. Now they are working with 32 PCs and a server (Interview, B. Abrehe, 10 December, 1997).

These are the government ministries and departments observed directly. Among those not accounted is the Ministry of Finance which has made significant investments in computerisation. Another heavy user is the Ministry of Defence. But in all these organisations the common trait is that these computerisation processes are island systems like stand alone workstations with few small LANs, The WANs do not exist at vet.

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12. Conclusion

This section on 'Science and Technology in Eritrea' shows us that there is a long way to go in establishing the infrastructure bases for the support of Eritrean industrial growth through science and technology. S&T policy-making body is non-existent. The country has been absorbed by the rehabilitation and reconstruction activities. The long-term development phase is only beginning to get some attention. Human resource development is getting the attention it deserves by Government of Eritrea as the base of development of the country. The country is aggressively trying to build its human resources skills, an example of which is the $60 million loan signed with the World Bank for the development of highly skilled manpower project. But at this stage there is no a conscious effort to link national economic development plan with national technology plan. The latter is missing completely. Research activities in the country are insignificant. It is not possible to talk of any kind of relationships between the university, the industrial research and development institutes, and the enterprises for an effective transfer of science and technology in the country.

12.1 S&T and economic policies integration

Eritrea is a new country established in 1993. Its first Macro Policy came out in 1994. This was followed by the National Economic Policy Framework and Programme for 1998-2000 recently. The national economic development plan exercise is a new experience for the country. But the country has a very rich experience acquired during the 30-year war of liberation where the first shape of the present government was being formed and some important lessons were learned in the political, military, social and economic spheres. Of course, Eritrea has also a very rich industrial experience during the Italian colonial period, particularly starting from the 1930s. This continued during the British administration in terms of light industry but the first dismantling of infrastructures did happen in this period. During the Federation Period, the Eritrean light industries continued to thrive because of the new Ethiopian markets. Afterwards, the beginning of the de-industrialisation process in Eritrea unfolded. We will use this rich experience to identify the lessons.

The present-day Eritrea with its political boundaries has been shaped by the Italian colonisation that started in 1889. But Italy's ambitions were not confined to Eritrea only. Ethiopia, as the only not colonised part of Africa, was also attracting them. Many economic historians have concluded that Ethiopia was a more viable option for a real colonisation in the classical sense. Eritrea, therefore, was a springboard for the colonisation of Ethiopia. For such endeavour, the Fascist Government of Mussolini was investing in Eritrea heavily. Transport and communications infrastructures got most of the investment and Italian entrepreneurs were encouraged to invest in light industries. At the base of this transformation was always the Italian skilled and semiskilled labour. Eritreans were at the margins of the modern economy. The Italian government had nothing to give to the local people except taking the best of their lands and its young for their military in the conquest of Libya and Ethiopia. It was not politically sustainable and it failed.

The twelve years of British administration did not change much of the landscape, except in expanding education to Eritreans but at the same time dismantled some of the infrastructure left by the Italians. But together with the USA, to suit their strategic interest in the cold war forced the federal arrangement with Ethiopia through UN. This is the seed of the next political instability in the whole region of the Horn of Africa for a long period. This is at the root of the process of de-industrialisation in Eritrea. The political and strategic interest of the superpowers took precedence to the legitimate aspirations of the peoples of Eritrea.

The Ethiopian government was more interested in gaining access to the sea and to exploit the industrial infrastructure existing in Eritrea, Again the Eritrean peoples' interest was secondary. Soon instability was to follow in the region. Both the peoples of Eritrea and Ethiopia were to suffer social and economic destruction. Both emerged poorer than used to be. But at least Eritrea got its independence.

What we have seen so far is a clear indication that political and or economic colonisation of peoples leads to instability and instability leads to economic regress. There are always alternatives to this. To involve the very people by gaining their consensus and co-operation and this should come first. There is no poor or small or weak country that cannot destabilise even a bigger one. The best solution lies in finding balance of interests. Even in the open market system, it is the balance of interest and mutual co-operation that leads to a working business relationship. Therefore, political stability is the basis for the economic development within a country or in a whole region of countries.

For the last seven years, Eritrea and Ethiopia had achieved a political stability and as a result the whole region had benefited. But recently, the old political game seems to have resurfaced and the border war between the countries is again creating a problem for economic progress in the region.

In the last seven years, Eritrea had made a significant achievement in the infrastructure development. A lean government civil service is put in place. A new constitution has been drafted and approved. The legal system is being revised. The macroeconomic policy, investment policies, fiscal and monetary policies, and industrial policies have been issued. The communications proclamation has been enacted, which will help the development of the communications industry. But putting in place a working physical, legal and informational infrastructure is not a matter of just few years. It is only the beginning and will take years to mature when the dynamics of implementation, learning, feedback and revision of the policies is fully in motion. Particularly the infrastructure to build the human capital will take time. To make the whole work in a sustainable form is a big challenge that the Eritrean government has to face continually.

l2.2 Priority given to IT

IT is not given any particular attention or priority. Eritrea is the only country in Africa without full Internet services, only e-mail service is available. But now decision has been taken to develop Internet and by the end of the year the country will have a full connectivity. PCs are coming in the country unrestricted and generally their utilisation rate is very low, mostly for word-processing only. Networked information systems are not yet known in the country. Very few government departments are starting to experiment with rudimentary LAN systems. It could explode any time if proper support is given in terms of proper incentives to computer busine.ss and the supply of critical IT skills.

12.3 Institutional capability

The institutional capability for the development of S&T that could be a real base and support for industrial technology development of the country does not exist. The country's administrative, legal, commercial, judiciary and regulatory institutions are still in the making. Institutions of higher learning and research are not fully developed.

University of Asmara, the only higher learning institution, is still at the initial stage of its development and it has a chronic shortage of local experts. Its new College of Engineering had its first graduates in 3-year diploma programme in 1998. The university's research activity is almost non-existent and it is being organised recently. Outside the university, there are R&D units in various ministries but at the stage of formation. Their main stumbling blocks are lack of funding and lack of experienced and qualified personnel.

There is still a great poverty of information in the country in general. This is a clear indication that the institutional support for generating information and disseminating it is absent. Particularly the culture of written information dissemination has not grown to the extent of creating a conducive environment for research and learning, whether it is in the civil services or the industrial activities. The government macroeconomic analysts find it difficult to come up with the right policies and the management of it simply because the data available on national income, fiscal and monetary developments, balance of payments, price indexes, demographics and other important social indicators are not fully available. The National Statistics Office has been established few years ago but its presence is not yet felt.

The telecommunications infrastructure is still poor by international standards. There has been a lot of incremental improvement in the last five years but it is not yet enough to meet huge demand. With the view of future computer network development, the existing telecommunications infrastructure is not reliable and sufficient to support its adequate development. As a result a substantial investment is required to really leapfrog and create a solid environment for IT development as the new infrastructure on which to base the future economic development. Eritrean government's attempt to make a joint venture with Daewoo of South Korea seems to have failed because of the recent financial crisis in Asia and/or the Ethio-Eritrean border war.

12.4 Human capital formation

The industrial development witnessed during the 1930-1960 was based on Italian skilled manpower. But at the same a considerable number of skilled Eritreans had emerged, which the country lost during the war of liberation. During this time, not only Eritrea lost the cream of its labour force but education in general was neglected. Particularly the primary education in the rural areas suffered the most.

After 1991 a very fast change in the whole education landscape of Eritrea is occurring. Primary schools have grown by 251 percent, middle schools by 161 and secondary schools by 190 percent. Technical and vocational education has also expanded significantly. Particularly the vocational training centres have increased in number providing courses of 6-8 month duration in a variety of skills.

In Eritrea, a lot of technical training is occurring at the firm level, given the small supply of formally trained technically skilled manpower. Particularly the metal and woodwork shops, auto-mechanic garages, various types of repair shops, electrical shops, and computer businesses are heavily dependent on their own apprentices and in-house training. The construction industry is increasing fast the poof of semiskilled and skilled work force through in-house short-term training, This is easily observable in the heavy construction machinery operation and maintenance skills and in new construction methods. The textile industry depends on the small private schools and some in-house training. The jewellery industry is completely artisan and depends exclusively on traditional apprenticeship method of training. The catering industry is totally dependent on in-house informal training, which is basically on the job training. But recently the Ministry of Tourism has started giving some short-term training.

The University of Asmara has tremendously expanded in the last five years. The number of departments offering degrees and diplomas has doubled from 13 to 26. A new institute, the Eritrean Institute of Management (EM) was established and is focusing on giving training to government public service employees. Recently, a new Human Resource Development Unit has been established at the university at the end of 1997 with the mandate of preparing the national human resource development plan and managing the 60 million project for the development of highly skilled manpower development supported by the World Bank.

Eritrea at present is suffering from a chronic shortage of highly skilled manpower to meet its development needs. But the country is trying to manage it by recruiting, for the intermediate period, expatriates (mostly Indians and Philippinos) to fill the most critical gaps.

IT skill in Eritrea is in short supply. Luckily enough for the country, some Eritreans from the Diaspora have come with the necessary experience and skills to establish a number of private computer schools and computing services businesses. This contribution has been a very welcome at a time when the country needed it most. But these commercial schools have their own limitations as well. They are limited to computer operation and some simple programming skills. Neither the university has taken the appropriate measures to tackle the problem. It has been slow to recognise the priority of IT in practice. The Computer Science will soon become a department but it will take at least four years from now to have the first graduates.

In Eritrea computers arrived almost without a warning with the end of the war of liberation in 1991. The scramble to acquire the basic skills from all types of organisations and from the existing and potential office workers was obvious. But as soon was made clear, the basic computer skills are not enough. You need to maintain a computer, to expand it, create networks, adapt the packaged software, develop new programs, develop databases, and most of all you need to design appropriate systems. The old way of organising work changes and a whole new way of thinking is also required. The country needs to be organised to produce the necessary IT skills in the future if a real leapfrog is going to happen in the use of IT as an infrastructure for all sectors of the economy to benefit and increase their productivity.

12.5 The Melting Pot: technology management and economic development

The case of Eritrea is unique in the sense that the country is new and the time needed for the melting pot to work is not there, i.e. S&T policies need time to produce change in relation to economic development. But at the same time, it has a great opportunity as a late comer. This is a time of IT revolution in the world. The whole world is in the process of learning of organising work and leisure in totally different way than it used to be. This is where Eritrea needs to jump to join the rest of the world and start organising work and leisure in a now way.

Therefore, the present research focuses on policies and projects undertaken so far in Eritrea or being implemented. It is basically a policy analysis on which to base the future development of the country. The experience analysed in Part I and II was meant to bridge the missing gap in the case of Eritrea. Now, a summary of past and present lessons learned from the experience of Eritrea is given. In the following chapter the future S&T in strict relation to economic development of Eritrea will be discussed.

12.6 Lessons learned

Eritrea has a very rich experience in what makes or breaks the industrial technology development, starting from the Italian colonial period through the years of struggle for independence and the recent post-liberation period. The major lessons are:

1. Sustainability

- The industrialisation observed in Eritrea during the 1930s and 1940s was mainly war related and could not be sustained once gone the demand on which it was based.
- During the 1950s and 1960s a more sustainable industrial development had to be found. New markets for the light industries in Eritrea had to be found in North Africa and the Middle East and the East Africa in general. But it was again mainly based on the large number of Italian investors and skilled manpower. Had it continued, it might have become politically unsustainable for the local people would be economically marginalised. But this last statement is purely hypothetical for the forced annexation of Eritrea to Ethiopia brought the war of liberation, which slowly drove away the Italians from the face of Eritrea.
- The de-industrialisation and the consequent destruction of the industrial technology of the country were the result of political instability. The nationalisation of the industries by the socialist Ethiopian regime and the consequent restrictions of private enterprise have also scared away DFI.
- The Ethiopian policy of deliberately halting investment in Eritrea, led to Eritrean skilled manpower exodus to Ethiopia and other neighbouring countries killing off further the industrial technology embodied in the know-how of these people.
- Ethiopian policy of control of highly skilled manpower producing institutions away from Eritrea so that newly skilled Eritreans were forced to migrate to Ethiopia for education and work at the expense of Eritrean industries and development.
- On the other side of the story, Eritrean resistance leaders had to make tough decisions of whether to find a reliable outside sponsors of their liberation struggle or depend exclusively on Eritrean resources. There were no alternatives than to make the Eritrean resistance sustainable on the country's resources and people. This opened the door to ingenuity and creativity. To make every tool and weapon or machines or trucks captured to last long by establishing in the bush machine shops and garages. Mobile hospitals, basic drags manufacturing and few other cottage industries to produce the basic items needed by the fighters had to be established and maintained. Skilled manpower had to be produced without institutions with sufficient facilities to do the job. These are the most telling lessons one can learn on how technology and skills can be used the most.
- Modifying, adapting and improving (at times paying human price) the available technology was relentlessly pursued and proved to be very critical to the military balance of power in the war of liberation.
- The resistance movement has learned that projects that cannot be financially and technically sustained are doomed to failure, therefore, not pursued.
- The greatest lesson of all is the ability to organise and fast mobilise the human resource. This was true in the past during the war of liberation, and it is true today in defending the country and in economic reconstruction, Examples are the national military service used to rehabilitate the infrastructure of the country and the summer reforestation and soil conservation program by the high school students. Recently in the bolder war with Ethiopia, these superior organisation and mobilisation ability proved again the asset of the country.

2. Flexibility and transferability

- Since the EPLF was the fighting force and at the same time administering the liberated areas for quite a long time, the boundary between military activities and that of civil administration was blurred. People and machinery were moving from the military to civilian works or vice versa as the immediate demand dictated. The same can be said of the technical knowhow.
- Even now, key government people keep moving from ministry to ministry and from department to department as needs dictate it. But this introduces also the risk of disruption in effective working teams.
- Government mechanical garages are being used for military and civilian purposes interchangeably making the most efficient use of the limited resources.
- The modern road building know-how, which started at the time of war of liberation, has tremendously grown in recent years. Local companies are doing big road construction projects on their own using modern heavy construction equipment and machinery. Sustainability is high because the work is all done by Eritrean skilled manpower and more are being trained. Support services are also growing side by side to it.
- The rehabilitation of the old railway using only local resources is also another good example of sustainable project as younger Eritrean generation is learning from the older ones.

3. Quality

- Eritreans have learned from the bitter war of liberation that their survival depended very much on the quality of their fighters and their motivation because the numerical and hardware advantage was on the other side. The same logic is being successfully used during the present economic reconstruction time.
- After the liberation there is an explosion of in-house training and seminars in all sectors. But more needs to be done to develop skilled and highly productive human resource and in particular to raise the culture of quality among the labour force.
- Eritreans have learned that superior organisational capability in mobilising resources and people and flexibility in their use can make wonders. It is being applied in the summer reforestation programme by high-school students nation-wide and the use of national military conscripts for economic reconstruction.
- Even today, in time of peace and reconstruction, Eritreans have transferred what was learned during the resistance time to work with what is available and stop dreaming and waiting for what is desirable to have first.

4. Priority

- No particular technology is given priority, But priority is given to education and human resource development, Top government officials are leading by example by undergoing study in Open University distance education in MBA, diploma and certificate programmes.

5. Result

- The country has been able to build a defence force very dependable with relatively lower budget.
- In the last five years the infrastructure of the country has improved visibly. The Lessons learned during the years of resistance are being used for the national reconstruction. But a lot remains to

be done to make the civil services more efficient and transparent and the country more attractive for investors, which is the base the future sustainable socio-economic development.

Particular lessons on IT development

It seems that an institutional framework to define policy issues and co-ordinate policy implementation is slowly emerging when one sees the proclamation No. 53/1994 on which EISA, at least legally, is founded. But the reality is different. ITPAC and EISA are not functioning according to the said Proclamation. It was supposed to I) develop, implement and review information technology policies; 2) to co-ordinate and manage Government information technology and systems; 3) provide technical advice and services. It does not have the institutional capability to undertake these functions. It does not have the necessary poof of expertise, facilities and budget to carry such a huge responsibility.

Organisationally, EISA is under the Office of the President. It is rightly recognised its importance by putting it at the very top of Government hierarchy. This stresses its importance and strengthens its negotiating position with other ministries. But its immaturity as an institution is the biggest hindrance to exercise its legitimate power to absolve its responsibilities.

Human resource problem is common to every Ministry in the country. The thirty-year war of liberation has deprived the country of the opportunities to develop its human resources. With regard to information technology, professionals and technicians and in particularly highly skilled personnel is almost absent. The human resource management is also at its infancy. It has been observed that retaining highly skilled IT professionals in government departments and agencies is one of the biggest challenges of the present Eritrea. Primarily this is because the private sector is more attractive to such professionals and there are very few of them. It is more rewarding to them to establish their own business both in terms of income and being boss of your own business. On the other side, the lack of professionalism in the management body of civil services obstructs the career development of such professionals. Fortunately for Eritrea, its people returning from the Diaspora are contributing a lot in the establishment of the computer industry. They are the ones that have come with IT skills and experience not available in the country. This happy coincidence should be properly managed to reverse the effect of brain drain by creating an environment conducive for highly skilled manpower.

It is not possible to say that Ministries were getting an appropriate budget to work with. As a result, getting funds for computerisation from the government was the last thing to expect, In fact, almost all these computerisation projects have been funded by donor countries or agencies. It is not possible to say the country is efficiently and effectively using these funding opportunities from international donors because of lack of strong institutions. To develop an appropriate IT base to support the development of good governance and modern industry, trade, tourism, transport and communications services, the country should have to know what it really needs. Projects should be designed accordingly and resources allocated to achieve them. Last, it should be able to manage the projects efficiently and effectively to achieve the socio-economic development objectives of the country. The country is beginning to learn and it can learn fast but the development of an appropriate institution to spearhead such a task must without delay be there.

There are a number of areas where fast learning is occurring. Business License Office has introduced a computer system to cut time spent in long bureaucratic processes that required people to go from office to office for weeks. Now it is an exercise of half an hour- NICE's insurance accounting system introduced have enabled it to keep it accounts up-to-date and reports are generated in three to four days what used to take a month. The treasury Department of the Ministry of Finance and Development has been able to establish computerised payroll system for the whole of the civil services. This used to be processed in each government department, agency and institute and sent to the Treasury for control and approval, a very time consuming exercise. The Ministry of local Government Head Office has developed a 50-user local area network with connections to two regional offices (1994). Eritrean Community Development Fund (ECDF) has a 50-user LAN with connections to two regional offices, Massawa and Mendefera, and an accounting system (1996-97). Ministry of Marine Reserves & Fisheries, Marine Resources Research Department has installed 10-user LAN (1994). The Eritrean telecommunications Services, the Eritrean Electric Authority, and Asmara Municipality Water Supply Department have all computerised their billing systems.

We have seen that various ministries are in the process of developing their own systems. Those that are developing networked information systems are the National Food Information System, in the Ministry of Agriculture; the Health Information system, in the Ministry of Health; Administration Information Systems of the University of Asmara; Information Systems of the Ministry of Industry and Trade, completed Systems analysis and design. The Bank of Eritrea and the Commercial Bank of Eritrea are working with some custom made software to automate some of their departmental functions, islands of applications. But they are still in the process of selecting suitable banking software.

Besides, there are hundreds and hundreds of standalone PCs in Government offices as well as private companies. The very concept of networked or distributed information systems is a recent phenomenon. Awareness in general seems to be rising. Computer schools and computer services business have contributed a lot to raising the general awareness of the public towards information technology, even though quality standards in many of them are very low which could be improved through accreditation and quality certification mechanism. The openness of the Government to information technology for the sake of increasing the efficiency and effectiveness of civil services is commendable. But the actual utilisation rate of computing facilities is very low. Some use it only for some word-processing activities. At the same time, it is not uncommon to see in government offices computers sitting idle in some places while in other places people struggling to complete work in the old manual method. They could greatly improve their productivity with the help of a computer. It is very logical to give facilities where it is needed most. For example if in the department there is only one computer available, instead of keeping it in the head's office for some word-processing activities, it could be better to use it for information intensive works such as the work of statisticians and information processing activities.

Nowadays it is possible to start with small number of highly skilled IT professional teams to diffuse the use of information technology immediately, if proper human resource plan and management is made. In Eritrea there is the possibility of using the already existing nucleus of skilled IT professionals that have come back from the Diaspora, for most the private computer services business is made up of them. At present these small computer businesses are working individually and a high degree of fragmentation is evident. Something should be done to team up these films to undertake major information technology projects. There is no doubt they would form a formidable competing force against foreign consultants and computing firms. Even computer assembly industry for export could easily flourish. The best way is to start by giving the necessary support to the private computing firms, particularly by establishing an efficient Customs Office with a tax and duties regime that supports to the developing the computer assembly business. Therefore, the various government policies should be designed to help the transfer of information technology conscious that this technology is a basic necessary infrastructure to make all sectors of the economy internationally competitive in the 21st century.

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13. Synthesis and conclusion

The future of Information Technology in Eritrea

This chapter is future oriented. It focuses on the second study question: How can Eritrea exploit best the opportunities offered by IT for its socio-economic development based on the experience of other developing countries? Based on the strategic policy analysis we made in the previous chapters, we will determine the best strategic options possible for Eritrea to exploit the opportunity to leapfrog offered by IT in its socio-economic development. It deals with the problem by taking II as an integrated part of S&T in general. It starts from the trend in S&T in the world and tries to show a possible path for Eritrea to bridge the gap in order to catch up in S&T in general and in IT use in particular.

13.1 Introduction and S&T trends in the world

In the 20th century the United States of America has dominated in all scientific and technological fields. Japan and Western Europe follow it closely. The three blocks basically have total control of the world's scientific and technological. The rest of the world is constantly looking unto them to catch up. This wealth of knowledge is at the basis of the control of the international trade and global economy. In fact, it is around these three blocks that a new global economic order is emerging, while the rest are straggling not to be left out as the irrelevant regions, particularly the SSA region.

Revolutionary innovation is occurring in all scientific and technological fields. Primarily advances in IT drive this wave of unprecedented changes, but it is much larger in scope than the information revolution - it is a technology revolution. Halal and his colleagues (1998) tell us that a wave of major technological advances seems likely to arrive during the next three decades and IT appears to lead this wave of innovation by roughly 5 years proving that IT .serves as the principal factor now for driving the technology revolution. Development efforts today mainly focus on the information revolution, which in turn drives other fields a few years afterwards. The information revolution should mature in the first decade of the 21st century, producing major advances in all fields. Multimedia interconnectivity will be dominant with virtual reality and large flat panel displays taking place of the computer monitor. Education, entertainment, commerce, and tourism will enter a new era of electronic access and sophisticated software will aid consumers and professionals by providing intelligent agents to filter news and mail. Moreover, expert systems will be used as surrogate doctors, lawyers, and other professionals. These capabilities will operate on ubiquitous microprocessors embedded in household products, walls, and automobiles.

In medical sciences, the medical community will have accepted the validity of holistic methods and computerised self-care; and new genetic strains of plants and animals will provide foods and customised farming. Alternative forms of energy, environment management, and transportation will also seriously begin to after life-styles. The biogenetic engineering revolution will permit curing diseases and their prevention through gene therapy, and it may then turn to that controversial frontier of improving the human genetic code. Farmers will genetically manipulate plants to improve yields and make them resistant to pests and spoilage. The cloning and/or manufacture of organs should help increase life spans. Composite materials, nanotechnology, and a variety of other methods will permit the production of almost any physical object, whereas Maglev trains, fuel cell powered cars, and intelligent transportation system should allow vastly improved mobility. Meanwhile, alternative energy sources, organic farming, aquaculture, and industrial ecology will serve to soften the hard edges of this high-tech world. The capabilities of intelligent and self-assembling materials, fusion power, artificial foods, and other advanced technologies will advance dramatically (ibid.). This is assuming that all the ethical and moral issued being raised by these scientific and technological developments are successfully overcome.

Advanced countries are investing huge sums of money in R&D in order to keep and advance their scientific and technological lead and by so doing control the new economic order. This is happening while in the developing countries, particularly in SSA, are still struggling to recover from the failed attempt made to restructure their economy on the basis of manufacturing trade and foreign direct investment in 1970s. The heavy borrowing made at that time, with the complicity of the lending-happy international banks, today it has become one of the main stumbling blocks of development (Castells, 1996). These were soon followed by the international financial institutions' interventions in the forms of 'structural adjustments', which created more problems than they solved. If in the past, developing countries sought science and technology development and industrialisation as a way of overcoming dependencies, today they have no choice but to try and try again to avoid the 'structural irrelevance' (to use the words of Castells, ibid.) posed to them by the new global economic order.

Information technology

The advanced countries have recognised very early the revolutionary character of IT and have tried to take advantage of it as it emerged. OECD (1988) says that IT has already demonstrated very great advantages in material-saving, energy-saving and capital-saving applications - for example, in the reduction of the number of mechanical and electronic components in engineering products ranging from cash registers to machine tools, or in the reduction of inventory. More fundamentally, the emphasis on labour saving process automation technology tends to overshadow the development of new products and services associated with the new technology. The experience of OECD (1988) countries has shown the main characteristics of present-day IT. There is continuing high rate of technical change in electronic-related industries themselves, as well as in a wide range of applications. These have led to the development of new types of data banks and information services, and have profound consequences for the integration and control of production activities. They have the capability to improve the quality of products, processes and services. It permits capital saving, labour-saving and energy-saving improvements in production processes since it reduces the number of rejects and wasted components for both intermediate and final output. Equally important, IT can link producers, wholesalers and retailers for it permits savings in inventories at all levels in the system, especially in work-in-progress, and more rapid and sensitive response to daily changes in consumer demand. Much greater flexibility in rapid model changes and design has been made possible. Some analysts have referred to this phenomenon as "economics of scope', replacing to some extent "economies of scale.

All of this means that IT is affecting not only the structure of the economy in terms of new industries and services, but also the internal structure and management of all enterprises and the relationship between them. There is a tendency in the more successful firms towards the horizontal integration of R&D, design, production and marketing, as opposed to the additional Tayloristic pattern of vertical, hierarchical control, People and information move more freely between the various departmental functions, and new channels of communication are established within and outside the firm.

If we let facts and figures speak for themselves, it is clear how important is IT to an economy and one cannot fail to see clearly its significance. Since IT is concentrated in the developed world, all the data we have is taken mainly from the OECD (1995, p. 60-63) countries. World production of electronic data processing and office equipment amounted to almost US$200 billion in 1991. Production was highly concentrated. The OECD area (excluding Greece, Iceland, Luxembourg, Mexico, New Zealand, Portugal and Turkey) is estimated to have accounted for 85% of this production while Taiwan, South Korea, Singapore, Hong Kong, Malaysia, and Thailand accounted for 12%. Only the US and Japan contributed 75% in 1983 and stood at 71% in 1991. With regard to employment in information technology, while the OECD manufacturing employment fell by almost 7 percent, a loss of 5 million jobs between 1980 and 1991, the office, computing and accounting machinery sector increased by almost I 5 percent, close to 130,000 new jobs were created.

Investment expenditures of the office, computing and accounting machinery sector in OECD Member countries amounted to US$10.5 billion in 1991. It was an average annual increase of 8 per cent over 1980 when they stood at US$4.5 billion, and a growth rate I per cent above that of investment expenditures in the overall manufacturing sector (7 per cent) [OECD, ibid. p. 70). The breakdown of revenues by source is not homogeneous for the nine countries for which data are available (Australia, Canada, Finland, France, Japan, the Netherlands, New Zealand, Sweden, the United States). However, in the early 1990s, data entry, processing and tabulation services, heavily weighted toward the latter two, accounted for close to or more than a quarter of computer services (France, 22 percent; Sweden, 23 percent; Australia, 25 percent; New Zealand, 28 percent; Finland, 29 percent). Revenues arising from various software and programming services (systems and user tools software, applications software, custom software development and programming services) accounted for close to a third of revenues in several of these countries (Canada, Finland, United States) and at least a quarter of revenues in others (France and New Zealand). An important part of the revenues is the computer services (between 18 and 26 per cent for France, the Netherlands, Finland, Sweden and Canada), the United States being a notable exception (only 4 percent). As for expenses, wages and salaries constituted, predictably, the largest single item. They accounted between 34 and 39 percent in Japan, Australia, Canada, Finland and France, 28 percent in New Zealand and only 22 per cent in Mexico (OECD, ibid. p.73).

Between 1980 and 1991, R&D expenditures for the office, computing and accounting machinery sector in OECD area grew by more than 12 percent annually to approach US$20 billion. For overall manufacturing, the corresponding figure was less than 9 percent. However, in t991, R&D expenditures in the OECD area fell for the first time, and a further fall occurred in 1992 (p.74).

In the United states, the number of patents granted annually in the IT field remained relatively stable between 1975 and 1985 (at a yearly "output" of around 10,000) and then rose sharply until 1990 (to about 16,000 per year'), to level off at approximately 20,000 thereafter. The relative importance of the regions shifted significantly between 1975 and 1993. Despite its "home advantage", the United States saw its share shrink by over 15 percentage points, to just under half of all the IT patents granted in 1993. Europe's share also declined over a period, from 19.5 to 12.9 percent In contrast, Japan almost tripled its share, from 12 to 32 percent, while South Korea, Taiwan, Singapore, Hong Kong, Malaysia, and Thailand have seen their share expand very rapidly since the late 1980s, even if that share is still a modest 3 percent in 1993 (ibid. p. 77).

As a proportion of the total number of patents granted in the United States, those involving IT increased from 14 percent in 1975 to nearly 20 percent in 1993. In 1993, for every 100 patents granted within the

United States to applicants from Japan or South Korea, Taiwan, Singapore, Hong Kong, Malaysia, and Thailand, over 29 percent were related to IT, whereas in 1975 the corresponding numbers had been 12 and 19, respectively. This rise in the percentage of IT-related patents for Japanese or South Korea, Taiwan, Singapore, Hong Kong, Malaysia, and Thailand applicants is exceptional. In the case of the US and European applications, the share of such patents in the total number of patents granted increased by only 3 and 2.5 points, respectively (p.77).

According to preliminary estimates of the World Trade Organisation (WTO), world merchandise trade expanded strongly in 1994, with growth of 9 percent in volume terms for the largest yearly gain since 1976, and a rate twice as high as in 1993. Growth of 12 percent in value terms, to more than US$4,000 billion, was boosted in part by a jump of about one fifth in trade in office machines and telecommunications equipment, a sector that includes computers, computer parts and semiconductors. The very strong growth of this product group raised its share in world merchandise exports to 11 percent in 1994, a figure that exceeds the shares of food, automotive products, chemicals and fuels (WTO, 1995).

All the above facts and figures show us how important is IT as an industry and as an infrastructure in the economy. In fact, The OECD countries have long ago recognised the pervasive character of IT and the importance of it to their economies. The ever- increasing investment in IT is the most compelling single evidence for it.

The economic importance of IT cannot be fully understood only by looking at it from the role it occupies in the economy at the present time but also from the role it will continue to have in the future. Glenn (1993) recognises IT sector as one of the fastest growing sectors in industrialised nations by emphasising the globalisation of industry. The industry is increasingly characterised by globalisation of technology with systems being designed in one part of the world, developed/manufactured in another, assembled in a third and marketed into particular locations or globally. Companies are taking advantage of areas of expertise, cost effective production locations, location of markets through the effective use of information and telecommunication technology. The goals of firms are increasingly directed towards global strategies, which find a balance between benefiting from the scale advantages of global markets while exploiting the geographically determined diversity of consumers and production factors. The MNCs organisation and production technology is and will be, structured to give it the flexibility to take advantage of diversity.

Globalisation has allowed firms to penetrate and service larger, geographically dispersed markets. Besides the "globalisation" of sales with the accompanying services such as marketing, distribution and faster after sales services, it now involves: production, including production of components; suppliers; investment, including intangible investment; mergers and acquisitions etc. Enterprises have become truly multi-national, operating at a global level, while giving importance to decentralisation (ibid.).

The term 'technoglobalism' was coined to describe the deep interaction between technology and globalisation that was inducing firms to bring about radical change both in their own organisational structures and in inter-firm relations. As the various corporate functions (R&D, design, production, marketing) are being integrated in order to respond to vaster and more demanding markets, new forms of transnational inter-firm co-operation are developing (ibid.). As a result, firms are making "networking" arrangements, since production for the world market is based in a number of units located around the world, each one enjoying a degree of autonomy while retaining its links with others. Greater and greater integration of computer and communications technology which will enable companies to offer virtually any service required by the public (Parapak, 1988) is what is happening today. Benjamin and Blunt (I 992), on the same vein, said that no company is an island and as a web of networks develops and people begin to focus on linkages across and outside organisations, key standards will be developed that will come to define "open systems" to support networking. The world is changing very fast and in the developed countries. Now we are talking about networked societies (Castells, 1996). As the old management tradition gives way to the new, managerial success will be increasingly measured by how effectively IT resources, relative to the immediate competitors, are deployed and utilised to best connect with and serve all stakeholders: customers, suppliers, workers and shareholders. That is, to position their organisation to benefit from the ever changing environment. In fact, IT is powerful tool similar to transportation technology in the sense that they both bring different individuals and societies closer in a new and revolutionising way.

Government agencies and business corporations are under constant pressure to change the structure of their organisations, offices and factories to increase efficiency and productivity and the products in information societies tends to be superior to those produced in pre-information societies. But, Youichi Ito (1990) warns against the threat of loss of cultural identity when foreign influence is overwhelming, beyond the control of the receiving country, or when influence is unidirectional for a long period of time, because psychologically delicate problems may emerge. This is particularly true for developing countries as they try to import new technologies from advanced countries. Youichi Ito tries to make his point by giving an example of a discussion he had with a friend, an economist. The position of his friend was that even if a country imports information products and exports raw materials and agricultural products. It should not be a problem as long as an even balance of trade is maintained and to retain a country's cultural identity is like believing in superstition and irrational. And he argued back by saying that people need a "balance of influence" apart from a "balance of payment". Therefore, it is very important to remember the impact of new technologies on the social and cultural foundations of the society. We cannot do more than agree to this important point. To keep the balance of cultural identity is very important.

Castells (1996) writing about the networked society says that 'networks' constitute the new social morphology of these societies, and the diffusion of networking logic substantially modifies the operation and outcomes in proces.ses of production, experience, power, and culture. These networks are open structures, able to expand without limits, integrating new nodes as long as they are able to communicate within the network. A network-based social structure is a highly dynamic, open system, susceptible to innovating without threatening its balance. Networks are appropriate instruments for a capitalist economy based on innovation, globalisation, and decentralised concentration, It may be good for work, workers, and firms based on flexibility, and adaptability. But it is based on a culture of endless deconstruction and reconstruction and a polity geared towards the instant processing of new values and public moods and for a social organisation aiming at the suppression of space and the annihilation of time. Yet the network morphology is also a source of dramatic reorganisation of power relationships. Switches connecting the networks are the privileged instruments of power. Thus, the switchers are the power holders. Since networks are multiple, the interoperating codes and switches between networks become the fundamental sources of shaping, guiding, and misguiding societies.

Given that advanced countries are the networked societies, the developing countries' hope lies in the possibility of developing a node of communication to connect with the networked societies. This can open a door to get access to S&T information available in the developed world and use it for their socio-economic development and, thus, partake in the new global economy.

It is very obvious there is a big gap between the advanced and the developing countries in terms of science and technology advancement. The level of advance differs from country to country even within the so-called developing countries. For example the SSA countries are at the very bottom almost excluded from the new global economy. The new competitive paradigm is based on technological capacity and technological capacity is mainly based on science and innovation, which is very scarce in the developing world. In R&D expenditures, while North America accounted for 42.8% of the world total in 1990, Latin America and Africa together represented less than 1% of the same total. In 1990 the G-7 countries accounted for 90.5% of high-technology manufacturing in the world, and were holding 80.4% of global computing power (US National Science board, 1991; UNESCO, 1990; Castells, 1996). The gap is, therefore, very huge.

Specifically coming to IT and its diffusion in developing countries, communications and information technology is still practically 100 percent imported (with exception in few technologies in the NIEs) from the industrial countries, requiring a considerable amount of scarce foreign exchange. There is, thus, a major gap between the need for IT and the capacity to purchase hardware, software and services (Parapack (1988). There is a shortage of skilled manpower. Technological and managerial expertise is still in the development stage, necessitating technical and management aid from the industrial countries.

While industrial countries are concentrating on developing and creating fully automatic and high capacity systems to exploit fully the economic benefits of the new technology, developing nations are struggling with job creation for the millions who are unemployed and with the provision of basic services in rural areas. Developing countries are constantly faced with conflicting objectives. Making trade-off decisions among objectives is extremely difficult. But to become reasonably self-reliant, every country must invest in S&T. At the same time countries must invest in productive activities to generate income and welfare for their people. There is also the need to attract foreign capital investment and venture capital to support growth. Yet, local entrepreneurs and businesses, which are best guarantee for technological independence, should not be placed at a disadvantage in the competition against larger foreign firms in their own markets. Greater co-ordination at the international level to help the poor developing countries is also necessary. But investing additional time and money in economically and politically unstable countries, which already are overloaded with foreign debt, is becoming an insurmountable problem.

Nonetheless, computers, particularly the microcomputers are diffusing in many sectors in the developing countries, including the poorest. Some of the NIEs in Asia and Latin America are even participating in the world market as producers. Singapore have gone as far as having in place one of the most advanced IT infrastructure in the world and it is even counted as one of the ten intelligent cities in the world (Newsweek November 9, 1998). In 1995 Brazil had 3% of the world market (WTO, 1995). India is participating in the supply of software with Bangalore city (one of the ten high-tech cities in the world) being the centre of its IT development, home of 250 high-tech companies, including home grown multinational software and networking giants Infosys and Wipro. Of course, if you move down the ladder of development to the least developed countries, IT becomes less and less significant. If there is some initial computerisation process, it suffers from acute shortage of infrastructure support to be of any significance. Particularly in the SSA countries, computers are mostly stand-alone workstations. Computer networking, where the real revolution and productivity lies, is still to come.

Policy analysis in this area will play an important role in understanding the actual opportunities available for development. The possible constraints that block such a development could be identified. Needless to say that the weaknesses a developing country has such as lack of skilled manpower and supporting institutions need be addressed before any worthwhile strategy for development is chosen. In the process of policy making, the assumption is that all the main players will be involved. In other words, this is not meant to be a dictation by governments. Governments do play a major role, definitely, but mainly as a co-ordinators and creators of a conducive environment where different government economic policies are used to give the right incentives without disrupting the market rather helping it to function effectively.

The alternative is to let the market forces shape what technologies to import and use. But in the developing countries' environment, where the market forces are not fully grown and mature, it would amount to a wishful thinking. For example, such a market is not present in Eritrea, for that matter in all developing countries. Particularly in the case of IT, even in the advanced countries, governments do intervene to maintain their technological competitive advantage or to have one. If we see Japan is trying to reduce the gap in S&T with the USA, while the latter is trying to maintain its world leadership. In both countries their respective governments are spending huge sums of money in this endeavour and they do it in cooperation with the private sector. But they don't simply sit down and let everything to the market mechanism. The same will be required of the governments in developing countries.

IT is widely recognised and singled out as the centre of the present wave of technological change even in the NIEs. They are heavily investing in it because it is considered the basis of future development. Today's world is highly informitised. Information is at the centre of economic activities and computers and communications are making the process of recording, storing, processing, and disseminating information very easy and cheap. One can say that we are coming to closely associate "wealth and power" to the control of "information and knowledge".

The question, therefore, is not whether IT is too advanced for the developing countries to master or appropriate technological choice. It is rather a question of whether IT can help the developing countries to reduce the S&T gap and enhance their economic survival or not.

No doubt developing countries are investing in IT. We can have a glimpse of it by looking into the international financial institutions' lending. Based on a database on Bank lending for information technology components in Bank investment projects, Hanna and Boyson (1993) analyse key regional and sector trends. This database contained almost 1,000 projects from fiscal 1986, 1989, 1990, and 1991, a portfolio representing about $100 billion in total investment lending. A major finding of the review is that IT lending is now an extremely dynamic business area for the Bank. It’s lending for IT (not including telecommunications) rose from $379 million in 1986 to $890 million in 1991, a 235 percent increase - six times the 39 percent growth in total Bank leading over the same period. The dynamism of Bank lending in IT has been largely the result of escalating demand by borrower countries for computing power that has become increasingly flexible, reliable, and lower in cost.

In the report, it is said that between 1986 and 1991, the Eastern Europe and countries of the former Soviet Union went from having the lowest regional share of IT lending to having the highest. Its share grew from $66 million to $330 million, even though the number of projects in this region was the lowest among all regions. This reflects a major increase in the IT intensity of Bank lending to economies whose financial and market institutions are being created or transformed. A spearhead project in this regard is the Hungarian Financial Systems Modernisation Project. Eighty percent of the investment in this project - or $112 million – is directed at creating a data network linking 240 branches of the 12 largest banks with the National Bank of Hungary for inter-bank accounting transactions.

The Asia region has had the second largest volume of IT lending since 1990. Consistent with the rapid pace of industrialisation and urbanisation, IT applications have focused on natural and urban resources management and on industrial modernisation and pollution control in projects in China, India, Indonesia, the Philippines, and Sri Lanka.

In Latin America, technology applications have tended to support the recent liberalisation of previously inward - oriented middle-income countries, and have been aimed at the modernisation of trade and finance, public sector management, and human resource development. Examples include the computerisation of customs activities in Mexico, public tax revenue and expenditures tracking activities in Bolivia and Jamaica, and education activities in Brazil and the Dominican Republic.

Finally the African region has had the largest number of projects with IT components of any region since 1986. The main focus there has been on automating data-intensive tasks in public administration, mostly in central ministries. Compared with those in other regions, IT components of Bank-assisted projects in Africa tend to be small and less complex.

According to the survey results of study made by Hanna and Boyson (ibid.) most of the managers had information technology components of $1 million or more in their projects, which in many cases represented minor components of much larger projects. The managers were extremely positive in their perceptions of the impact of IT. Among survey findings, 78 percent of respondents perceived that - to a great or very great extent - IT was critical to achieving project objectives. About 85 percent of the respondents expected major or transformational improvements from IT applications in their projects. The most frequently cited improvements: better financial management and reporting, improved co-ordination between organisational activities, and improved organisational response to beneficiary or market needs.

More need be done to avoid the increasing isolation and marginalisation of developing countries for information technology plays a big role in bringing the new global economy (see Porter, 1990; Piore and Sabel, 1986). What is new is not so much that international trade is an important part of each nation's economy, but that a national economy works as a unit at the world level on real time (Carnoy, 1994). The new information and communication technology make it possible for all countries with the technology to gather and act on information at breakneck speed, to move products world-wide, and, with the proper approach, to gain access to capital and highly skilled labour from a world-wide poof.

There is more to this, the concept of Third World as such has disappeared (Castells, 1993). According to Carnoy (1994) what used to be known as the Third World economies are now different economic groups redefined in terms of their relationship to the world economy by their ability to produce goods and services related to information. They are broken up among four groups. First, the clear winners are the rapidly growing newly industrialising countries of Asia. Second, follow the potential winner countries such as Mexico (as part of a North American free trade area), Argentina, Brazil, Chile, Colombia, and Venezuela, the recovering relatively highly educated Latin American societies. As a third group come the large continental economies of India and China on their way to integration in the new-world economy primarily because of their potentially massive markets and large stock of highly skilled human capital. Finally the clear losers come, the Fourth World of marginal rural economies on all three continents and of Africa's and Latin America's sprawling urban peripheries.

Potentially there are high payoffs from "successful" IT investments in developing countries. But the severity of institutional weaknesses and information gaps in developing countries puts a high premium on setting the enabling policy environment, diffusing best practices, investing in complementary inputs, training local staff, and developing the infrastructure and support services to realise and sustain such payoffs. In order to avoid such pitfalls, a strategic approach to Information Technology lending must be adopted (Hanna and Boyson, ibid.). Currently, IT applications are typically incorporated as a component of an investment operation in response to specific needs of the project, with little appreciation of information needs within and across sectors. As a result, information systems are often disparate and isolated, within little capacity for sharing data, and they sometimes provide overlapping of conflicting functionality and incomplete coverage, even when concerned with a common function within the public sector, such as financial management. Lending to isolated and specific IT applications may not also address the policy, skill, and infrastructure factors that are often critical to the sustainability of these components and to the effective assimilation and diffusion of the new technology.

IT can be used to capture and mobilise local knowledge, to disseminate it among institutions and economic agents, and to blend it with global knowledge. It is enabling technology, indispensable for competing in an increasing number of global industries and services. To exploit the potential of IT, developing countries need to overcome various barriers to diffusion. They also need to develop new infrastructure and networks. And they need to invest in new skills and learning. Developing the systems, infrastructure, and capabilities requires a strategy and no small amount of co-ordination among public, private, local, and foreign actors. Perhaps the biggest opportunity IT holds for the public sector is to inform policy analysis and strategic management, to improve monitoring and accountability, to facilitate participation and lateral communication, and to enhance learning and feedback.

Particularly in developing countries, improved information and communication systems could enable public institutions to respond to rising demands for diversified public services, new modes of delivery, faster transactions, and more transparent processes.

Developing countries and aid agencies need to keep pace with the associated technological, organisational, and human resource imperatives. They also need to overcome various-barriers - in the adoption and diffusion of new technology and in the investment in new skills, practices, networks, and infrastructure. Particularly the enabling technologies such as IT need be singled out and given priority, at least to be able to get access to the scientific and technological knowledge that the present world has been able to accumulate. It is in this line that Eritrea needs to come up with new and bold initiative in IT development.

13.2 How to bridge the gap?

We have just being exploring the trend of IT revolution in the world and it is very clear that developing countries are running after a moving target. Catching-up in S&T and economic development when advanced countries are moving at a faster rate of change in every field of knowledge is a daunting task. Even though it looks as an impossible task, Eritrea, as a latecomer, has to study the opportunity of learning from the success or failure of others before it. With government clear vision and leadership commitment, a careful plan to bridge the gap is a possibility (no matter how long it takes) as demonstrated by the experience of the NIEs. But the road is full of caveats, the country need to avoid the common mistakes made by SSA countries in the industrialisation process. In the following sections, we will discuss about the leapfrogging possibilities available to Eritrea. First, we will discuss about the necessary conditions to set in motion a viable development without which any development process cannot take place. Then, we will elaborate how the S&T for development can be established in Eritrea - from the general to the specific IT related leapfrogging possibilities.

If we start from the experience of SSA countries, which in general is considered a total failure, the lessons are clear for everyone to see. The conclusion we have drawn in Part II, in short, was that a viable solution to the African problem has not been found yet. But one thing is clear: SSA countries do not have the necessary technological base to effectively compete in the global markets. We have said that there is no way out except they need to re-invent themselves. They need to rethink of the way their governments, their industries and markets are organised and managed. With regard to the creation of internationally competitive industrial capacity, they should be able to create a strong S&T basis. Now using the case of Eritrea, we will try to show how to reverse the current situation. Before, let us briefly see what we are going to do starting from the creation of an environment conducive for development. The following points show what we mean by conducive environment:

1. Create a conducive environment for development such achieving political stability, creating efficient government administration free from corruption and accountable to the people (leadership and managerial capability), and develop a network of regional and international co-operation;
2. Develop realistic and sustainable economic development strategies, have appropriate policies, develop the human resources, develop the institutional capability;
3. Develop science and technology policy to support the socio-economic development and in particular to develop the industrial technology base;
4. Raise required funds for investment and allocate and use these scarce resources efficiently;
5. Develop proper implementation plans and manage them effectively and efficiently;
6. Evaluate and follow up the implementation and adjust or upgrade them in line with the changes in the political, economic and social environment.

In this section, we will continue to discuss about the environment conducive for development in Eritrea. In the next section we will continue to discuss about policies. If properly used, these can be very effective tool to plan and co-ordinate activities at the national, sector and industrial level. It is within this framework that we are going to discuss the remaining case of Eritrea.

The right environment

To begin with, any country needs the right environment for development to take place. These include peace and stability within the country and without. The SSAs experience has shown that its absence has created destruction and under-development. Plundering state assets and wealth became common. Ethnicity has been used for political power control games with devastating effects. Too many military coupes and dictatorships running countries under their grips through corrupt government administrative systems too busy enriching themselves to give attention to real issues of development. When accountability is put down the drain, anything can happen but development.

Eritrea was not in the right environment for development in the 30-year war of liberation that ended in 1991. The last seven years were a good example of the right environment for development. Unfortunately that is again tinted by the recent border conflict with Ethiopia. This needs to end peacefully soon in exactly the same way as the border dispute with Yemen was solved.

Eritrea, on the other hand, is very lucky to have a clean government very committed to development. Internally, the country is united and there are not problems of ethnic conflicts that could lead to destabilisation. The government administration is not big and administrative bureaucracies are very limited. The government has openly debated the formation of a lean and efficient government administration and is making progress towards it. But it is obvious professional administrators and managers are in short supply in the country. It is a problem the government has recognised and is dealing with it investing heavily in highly skilled manpower development. It has also recruited a significant number of foreign professionals and academics to limit the critical shortages. But more need to be done to limit brain drain problems.

Debt mismanagement is one of the causes of underdevelopment. There is a big lesson that Eritrea could learn from the SSA countries, the problem of debt. The debate on the debt crisis in Africa is not over yet and there are different ways of explaining it. One thing is sure, though, that heavy unscrupulous borrowing and the following mismanagement are at the root of the debt crisis. Now that Eritrea is looking for ways to get the necessary fund to develop the infrastructure required to attract investment and lay down the basis for industrialisation, borrowing will definitely be there. It is inevitable and necessary. What shall Eritrea do? It needs to acquire the expertise in debt management and project management so that the funds are properly used. But more than anything else a clean and accountable government is the answer. Eritrea needs to continue to build a culture of transparency and accountability to keep corruption at bay from its environment. Government crisis management retards scientific and technological development. Usually when governments overspend and create a considerable public deficit, they start to introduce austerity measures which at times result in sudden cuts of budgets across the board. The first to suffer from these cuts are the very public institutions that were created to give the structural support for the necessary technological capability development (e.g., the experience of Brazil we have seen in chapter 5). As a consequence, a chain reaction follows, which ends up in paralysing the development of the whole country leading to its stagnation. Therefore, Eritrean government expenditure should be kept under control (particularly military expenditure). Any political decision that may lead to such possibilities or extremely fast and huge infrastructure investments should be avoided (accelerated development financed through substantial external borrowing) because it is the major cause of debt crisis of the 1970s in developing countries. Any expenditure should be related to the ability of the country to absorb the know-how and the efficient use of the infrastructure developed.

Government role is determinant as a catalyst in economic development. Governments play determinant role in the economic development of developing countries. The case of Singapore shows that clearly. The strategic moves made by the Singaporean government were, first, to draw in MNCs, which were searching for labour intensive operation bases in the second half of 1960s; second, to establish shipyards and defence industry as well as attract oil related companies in late 1960s; third, to make l0-ycar economic upgrading plan and rapid expansion of technical tertiary education in late 1970s; fourth, to pull in MNCs in new growth industries in early 1980s; finally, since 1985 it is encouraging entrepreneurs, overseas ventures and MNCs to use Singapore as regional hub, push for R&D and innovation, and go for economic alliances to capitalise on the boom in Asia. It is working. Eritrean government can learn this dynamics and play its role as a catalyst in the technological and economic development of the country.

Most often African countries have failed to bring stability in their environment, to create an accountable and efficient government system, and support the right technologies for the development of industry. They are most of them deep into the vicious circle of underdevelopment and their people have accepted poverty, diseases and illiteracy as a way of life. Each one of these things is very important and a real courage and determination is required to act immediately to achieve them. The right state of mind would be to believe in oneself. Africans have to believe that they have the capacity of solving their problems with their own resources. Many have very negative and very pessimistic view of Africa. Even Africans themselves are tempted to believe in some sort of fate, which is mercilessly keeping Africa chained. Africa needs to look at figures like Mandela and hope to rise above its current difficulties. Luckily for Eritrea, there is no short supply of the right attitude to development and self-reliance because of the long war of liberation experience. This country firmly believes in its ability to raise above all odds and win. It believes in education as education is at the basis of every change. During the darkest periods of struggle, education and training was going on under the trees in the bushes and in the bunkers. There is no need to wait for school buildings before we could start teaching and learning. In a world moulded in the capitalist system, only the 'fittest' can survive. We need to think like the desert plant. Its world is made of scarce water and not of plenty. It survives on its ingenuity because it has developed drought-resistant characteristics. Exactly, Eritrea has used its ingenuity to come with creative solutions to its problems depending on its people and the available scarce resources. That is what it needs to continue to do also in the future because catching-up is a possibility.

Which are the right S&T policies for Eritrea? First of all, there are no so called 'best policies of strategies'. Second, there are a number of possible right policies for a given country at a given moment in history, and Eritrea has a number of possible choices. In short, the S&T policy should be firmly based on the national economic development plan of the country, it should be the one the Eritrean leadership believes in and is committed to follow consistently for a long-term. This implies that a national consensus of the leaders (political leaders, leaders of the business community, leaders in the scientific community, and the opinion leaders from the public in general) must first be achieved and then institutionalised through national policies and strategies, or legislation, or some other ways to ensure long-term commitment. It implies also that it should be consistent with other government policies. In addition, to gain support of the people, it should be promoted widely.

Clear vision, action and learning, consistency, determination and perseverance in action are very central. Eritrea should work with the same tenacity and perseverance of its thirty-year war of liberation in this war against the worst enemies: poverty, diseases, and illiteracy. There are no quick solutions. Its S&T policies should clearly and explicitly aim at the eradication of the above mentioned enemies. Above all it should focus on the development of managerial capability building because even the best of the policies and intentions fail without it. Learning, learning and continuous learning at the government level, enterprise level and individual level are a must. Therefore the culture of learning through experience and education should be the foundation blocks of its long-term development programmes. Today IT has invaded the world and every aspect of our life is becoming 'informitised'. It is a pervasive technology and a very good tool for knowledge creation. Access to information and knowledge is exclusively dependent on it. If the culture of change and learning is to be realised, Eritrea should see and invest in IT with interest and care. On the other hand, it is not possible to avoid it because the trend is that every human activity is revolutionised by it. Eritrea cannot afford to be left out.

The right people

Human resource development, use and retention are crucial. Another important lesson from African countries is that developing skilled manpower is not enough by itself. It is what you do with your skilled people that count most. There is a big problem of 'brain drain' in developing countries. It is very pronounced in Africa. Besides the human resource underutilisation in Africa is a big problem, Therefore, Eritrea should from the very beginning learn to efficiently manage its human resources. This means that every possible incentive should be used to retain the skilled people because the country has invested in them and they are a critical factor in the development of technological capability. If you are not able to do so the dependence on foreigners will continue at a much higher cost and the vicious circle will never be broken down. Giving these highly skilled people the remuneration and chance to fully participate in the political and economic sphere of the country could be a good motivator to retain and utilise them properly.

At the present time in Eritrea, the government is playing a very central economic role and it seems the same trend will continue for the foreseeable future. The task is huge and requires highly skilled manpower at the top echelons of government. Since the beginning of 1996, the top Eritrean government officials, including the president of the country, are undergoing the

MBA training with the Open University of UK. This attitude toward education shown by the government is the future hope of this country. Education and training are in general given priority and are expanding very quickly. How far will all of this go? It is to be seen yet. But the Macro Policy (1994) and the National Economic Policy Framework and Program (NEPFP) are clear about it. Human capital formation is rightly considered the basis of development of the country. Evidence to this is not only the rhetoric of the government officials but the US$60 million project for highly skilled manpower development funded by the World Bank. There is no doubt the country is in the right direction.

The right institutions

Institutional proliferation in the name of developing the institutional capability should be always avoided. This is particularly true for countries small and poor like Eritrea. First, the existing institutional capacity within the ministries should be fully utilised. To make this happen, an inventory of such capacities should be made and their services made available to all. The consequence of this will be the adoption of highly flexible and open organisational structures and organisational culture as well. Second, where more of institutional capacity is required, all potential users should be involved in the making of them so that the possible antagonism and rejection between the established and the new institutions is avoided. In Eritrea there is poverty of visible institutions but very flexible mission oriented task forces are continuously formed and disbanded at the government level to address many national issues in the meantime the new emerging institutions take their place. Important development decisions continue to be taken and infrastructure works are moving fast relative to the resources of the country.

Even though entrepreneurship in Eritrea is not new thing, it is not playing a central role in the economic development yet. It should occupy its rightful place as a central agent of innovation and development. In fact, what the government should do is to act as a real entrepreneur itself (like Singapore). This would stimulate, facilitate and prepare the ground for the growth of entrepreneurs in the country. The privatisation programme initiated by the government is moving ahead in the right direction. Nineteen out of the forty-two public enterprises (excluding utility services) have been privatised so far (Eritrean Profile, May 15, 1999). But appropriate institutions should be established to look after the needs of entrepreneurs such as credit facilities, information centres, and consulting services.

The right technology

The experience of the Tigers shows that starting with simple technologies in the light industries and go integrating backwards into heavy industries as well as the high-tech industries is a more sustainable strategy. Similarly, Eritrea can go immediately for the light industries for export, for example, in textile, leather, salt, fish, vegetable and fruits, dairy products, glass and marble, and other construction materials production industries. The government could play a catalytic role by promoting well-tested technologies and see their diffusion. But it is not said that some small high-tech firms cannot be established profitably as evidenced by the experience gained in Fred Hollows ILO Laboratory in Asmara.

Eritrea can leapfrog using IT. Eritrea by investing aggressively in highly skilled manpower can leapfrog into the IT use, particularly to support the development of the service industry such as trade, tourism and other social services. As IT professionals increase in number, then, the software industry can be considered. Once you have created a critical mass of such manpower, it is possible to creatively use it in particular segments of that market. On the other side, it could enable you to exploit the full potential of imported IT technologies in terms of adaptation to local needs in all sectors of the economy because IT is a pervasive technology.

Eritrea can learn a lot from Singapore in developing IT infrastructure for becoming a trade and service-hub in the region. The Eritrean government has made it clear in its macro policy (1994) that the long-term strategy is making Eritrea a service-hub in the region. In this respect, Eritrea has a lot to learn from Singapore. Singapore has one of the most efficient and modern ports in the world, so Eritrea can learn how to transform its ports of Massawa and Assab to make them internationally competitive. Singapore is a financial centre in Southeast Asia so can be Eritrea in the region of East Africa. Singapore is a teleport in the region so can be Eritrea if it takes all necessary actions to learn quickly the tricks of the trade from countries like Singapore. The same can be said of tourism. Eritrea has one of the most beautiful and unpolluted beaches in the world with about 360 coral-reef islands in the Red Sea. These can be changed into a thriving tourism sector. To exploit to the fullest potential such tourism, Eritrea needs a good international airport well integrated in the international air services system. For all these Eritrea needs to develop a modern IT infrastructure for the 2lst century in the coming decades. Singapore has a very sophisticated IT infrastructure that has been able to build in the last 15-20 years, so it is possible to take Singapore as a model for Eritrea. The only qualification we need to make is that any model cannot be a perfect match; therefore, whatever Eritrea imitates from other countries should always be adapted to its regional scale and local socio-economic situation.

In the process, the Government of Eritrea should play a catalytic role in the development of IT manpower and computerising the public administration. To do so it needs a proper S&T policy-making body to determine priorities and co-ordinate activities in the creation of an effective national innovation system. It should also support the diffusion of IT application among small and medium-size enterprises, promote software and computer services, mobilise local and global information resources, and induce collaboration among public, private, academic, and foreign agencies. The remaining part of the chapter is devoted to the discussion of how Eritrea can establish S&T policy-making body and an IT board to make sure the opportunities offered by this revolutionary technology in order to leapfrog intermediate stages to land on the stage where the country can effectively use IT in particular in trade, finance, tourism, transport and communications and other social services.

13.3 S&T Policies

When we talk of science within the context of the developing countries like Eritrea, the emphasis is going to be on the application of science and technology first and foremost. Developing countries, as late comers, have one advantage in the sense that they don't need to reinvent the wheel. There is a lot of scientific knowledge available to it from which to select and use to solve its problems, though at a price. The same can be said of technology. It is very important to remember Kim's model (chapter 2 and as seen in Part I), which is based on the experience of South Korea. The model argues that fast catching-up is possible for latecomers by starting from importing and assimilating mature technologies. Therefore, Eritrea can choose the right technologies and effectively use them to solve its problems. But even the so-called available knowledge at times seems to be very inaccessible to those who need it most. This is because to be able to choose you need to know. If you don't know how can you choose what you need? That means knowledge is at the basis of every change.

The advances made in S&T in this century is tremendous. Particularly the pace of change seen in second half of this century has no parallel in the human history of development. But unfortunately these advances are not evenly distributed among the countries. The previous chapters showed that clearly. The diagnosis in our research focused on the NIEs, the Sub-Saharan African region, and of course Eritrea. At the beginning of this chapter, we have seen the trend of development in S&T occurring at the world frontier.

Finally in this last part, we are exploring the possible solution for Eritrea to develop its S&T base for socio-economic development in the future.

Our point of departure will be the policy-making activity, in terms of its process and content. While we touch the broad S&T spectrum, we will continue to focus on IT as the pervasive technology that need be given priority as an infrastructure for the whole economy and in particular the services sector, which is of strategic interest to Eritrea. First, the study will identify the unique characteristics and situations of the country that help or hinder the building of S&T for a sound socio-economic development and prepare a plan of action commensurate with the capability of the country to absorb and diffuse it. To enable a least developed country like Eritrea to be fully integrated into the global economy, it is a long time process. What is important is to keep the country connected immediately, first, and progressively integrated fully, later.

Vision and objectives

We had seen that the Lagos Plan of Action defined the long-run objectives of SSA countries as is 'sustainable economic growth combined with social justice'. We have seen also in Part II how the SSA countries have failed to integrate S&T to the long-term development objectives. How could Eritrea achieve these?

First of all, let us divide into more convenient and implementable socio-economic development objectives and try to link them with S&T objectives. Stewart, Lall and Wangwe (1992) divided the so-called 'sustainable economic growth' combined with social justice' in four vital sub-objectives. Below, we give an example of how Eritrea could integrate these four possible major economic and social objectives to S&T policies that can support their achievement:

1. The attainment of a viable balance of payments. To help achieve this, S&T could be designed to help:
   - increase labour productivity through education and technical training;
   - increase industry's productivity by supporting technology transfer negotiation and implementation;
   - increase the knowledge base of industries by providing databases of markets and new technology development information;
   - industrial research work in co-ordination with manufacturing firms to produce and commercialise new exportable products;
   - Improve management and office-work productivity using IT, and allow a real-time business networking with suppliers and customers.
2. The achievement of sustained growth in agricultural and industrial production. S&T can contribute in the achievement of this objective by:
   - Agricultural research: seed improvement, cattle breeding, pest control etc.;
   - Environment conservation, combat expansion of deserts, accelerate forests growth water resources management, etc.;
   - Developing environment friendly agro-industry and fisheries technologies;
   - Guiding a balanced growth of the economy with the wild life and nature conservation.
3. Full participation of the labour force in productive activities, at adequate remuneration. This can be helped if S&T policies of the country focus on the human capital formation of:
   - Giving continuous training to employees to make them employable;
   - Minimising brain drain of highly skilled manpower by increasing the technological base of industries and creating conducive environment for innovation and work in particular that of scientists and engineers;
   - Protecting the rights of innovators.

4. Comprehensive access of the population as a whole to basic needs including basic health care, basic education, food, water and sanitation. This has to do with the equity side of the equation, and S&T can contribute a lot by:
   - Designing a preventive health system and efficient and effective health services;
   - Promoting relevant research on health problems peculiar to the country (like eradication of malaria and other tropical diseases);
   - Designing relevant curricula for education system and regularly update them;
   - Developing a higher education system more relevant and linked to the country's economy (pushing the scientific frontier should not be the main aim or avoid creating scientists and technologist more in tune with the advanced countries' needs rather than their country);
   - Developing a scientific body capable to give consulting services in all scientific, technological, social, economic and political areas;
   - Improving city (town) planning and housing in line with access to safe water and hygienic dwellings.

Of course, this is a sketch of how we could proceed to do it. Otherwise, each economic sector needs to commission a study on how best to link S&T policies to support the socio-economic development objectives of the country.

Getting access to the scientific knowledge it does not make one capable of producing things based on that knowledge. You need to master the technology. To master technology you need money to buy it and time to learn it. On the other hand, in a free market system, only the fittest can survive. In a world dominated by the developed countries, the least developed countries are most vulnerable and weak and are even non-existent as players in the world market. If we can use the analogy of the firm, a firm that cannot compete loses its market and is bankrupt. It ceases to exist. It is almost the same with the least developed countries with the only exception that you cannot wipe them out of the map as in the case of a bankrupt firm. Particularly if you see those heavily indebted countries, it seems they are given periodic debt restructuring and some additional financial loan from the Bank or the IMF to keep them alive to continue to pay their debt. All experts agree that these countries cannot break down the vicious circle but this is what a free market system means. There is no room for emotions. Every new born child in these countries has a debt burden on his shoulders which in the future make impossible for him to be educated, become a scientist or an engineer to solve his peoples' problems. It seems that the world has accepted the fact the child pay for the mistakes of his parents for heavily borrowing in the past. What about those who have given loans on risky projects? Fortunately, Eritrea does not have any heavy burden debt, as is the case in many SSA countries. This means that it has a better chance to build its S&T infrastructure based on the experience of others.

But Eritrea does not have an explicit S&T policy, nor does it have a separate policy-making body. The Macro Policy (1994) makes some broad statements, which we will sec later. With regard to IT policy, an attempt had been made to establish an Agency, EISA, to advise on policy matters to the Office of the President but no national IT plan has been produced. The Agency does not have the required institutional maturity to undertake such a task.

Who is directing the scientific and technological development of the country, indirectly or multiplicity, are the investment policy and the export-led free market policy that the country has embraced. The investment policy is trying to attract foreign direct investments to the country, looking particularly to the transfer of modern technologies that can make the country more competitive in the international market. Joint ventures with the Government are encouraged. The Government is aggressively promoting partnership rather than aid as a reliable base for long-term socio-economic development.

One of the attractions given to potential investors by the Government is low tax and free movement of capital and profits. Export tax is eliminated. This is designed to increase private investment, local or foreign, to come forward with new technology and efficient and effective management to be able to produce goods and services for export market. Therefore, these policies are expected to create an environment conducive for the market to select the right technology, possibly advanced technology if it is to be able to compete in the international markets.

Scientific research in the country is only beginning. With the new structure in the civil services, research and training departments have been established in every Ministry and, at least in theory, have been given the autonomy to undertake research activities. But they are all at the rudimentary stage. It is very difficult to expect much from them in the near future before they could get appropriate staff for the job and the necessary budget, the most difficult hurdle in the process. Budget making requires institutional maturity if it is going to serve effectively the country. And no institution can survive without the necessary budget. In Eritrea, to build a national innovation system, S&T need be institutionalised and the policymaking body need be established to decide in national priorities and given the required budget to implement them. This will be our next discussion.

Institutions are very central to the development of S&T. It is known that there are 'market institutions' and 'non-market institutions'. Market institutions are established to give services at profit. If profits decrease or are long to come, these institutions are not attracted. For example, in Eritrea the private enterprises are all small sized. Long-term investment is less attractive to them. Investment in research is out of their sight (the same has been observed in NIEs in Part I). Therefore, a non-market institution is required to fill the gap and undertake some research activities to adapt or innovate, if successful competition in the world market is to be realised. This is where the intervention of government becomes a necessity.

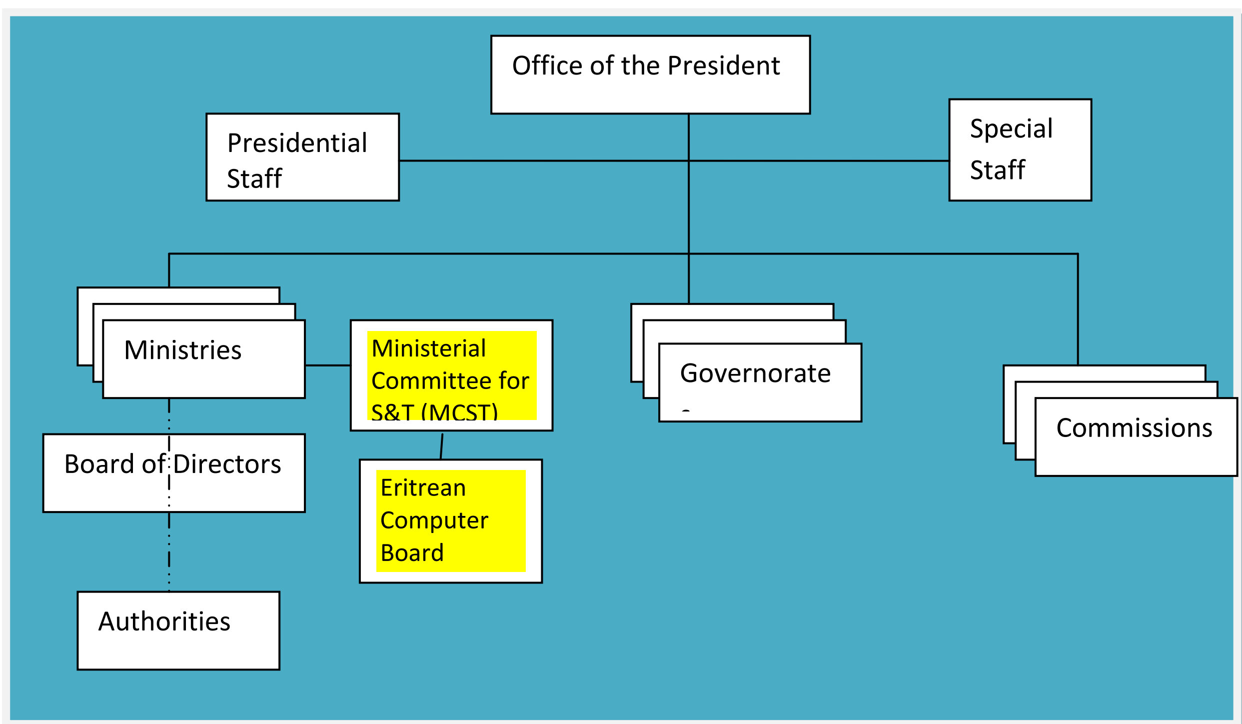
Governments in South Korea, Taiwan and Singapore did it when the private sector was not in a position to do it (see Part I). Providing skilled manpower and expertise to support the rise of, the small private businesses to international competition is a public good. The government needs to invest in it. In fact, every government in SSA countries is doing something already. But it needs to be more consistent and systematic and based on own resources, though with the assistance of the international community. But it cannot be based on the whims of donors or NGOs. It is an infrastructure the country itself need invest first. An institutionalised body is required to build this infrastructure progressively and systematically. Eritrea needs to act immediately to lay the founding grounds.

Policy-making bodies direct and co-ordinate all S&T activities. In Eritrea, even though separate S&T policy-making bodies are not created, it does not mean S&T policies are not made in the country. These explicit or implicit policies are made somewhere. A Ministerial Committee, a Ministry, or a Commission (or the industry itself) may initiate it' or it may be the result of the interaction of all of them. In the case of implicit policies, different Ministries policies and activities do create a conducive or less so environment for S&T development in the country, which slowly emerge as a norm. Now what is required in Eritrea is to recognise the strategic importance of S&T and make sure someone takes the responsibility of it.

Generic statements, such as those given in the Macro Policy, are not enough. Saying 'research and development efforts in selected sectors' is vague till somebody tells us which are these selected sectors or priority areas. We need to know how it is going to be done, who is going to do it, when it is going to be done, how much is going to cost us and what are the expected results. Similarly saying 'keep Eritrea abreast of developments in production' tra6sport and service technologies in order to assure an upgraded and modern economic system that is competitive in the world' is vague. It is too general to have any directional value to the country. Somebody needs to interpret it and give direction to all partners in the national innovation system. Each R&D department at ministry level cannot, on their own' undertake this responsibility.

Therefore, the role of the policy-making body, which we will call it Ministerial Committee for Science and Technology (MCST), would be to give a clear direction through its S&T policies. Everybody should know which particular technologies are selected as the target group to develop the industrial technological base of the country. For example, in each sector of the economy there are many available alternative technologies, which ones do we give priority and promote? In agriculture drip-irrigation is very important for an arid zone like Eritrea. Desalination technology is another alternative very important to supply water for drinking and agriculture because the country has more than 1000kms of arid coastal lines potentially fertile. It could be animal husbandry technology for the country is rich in animals. Further, it could be modern port facilities and transport technology, like containerisation technology; sustainable fishing technologies; modern construction technologies and methods; and IT as a basic infrastructure for the financial sector, trade, tourism and other services if the country wants to be financial and services hub in the region etc.

Figure 13.1: Ministerial Committee for Science and Technology within the government structure.



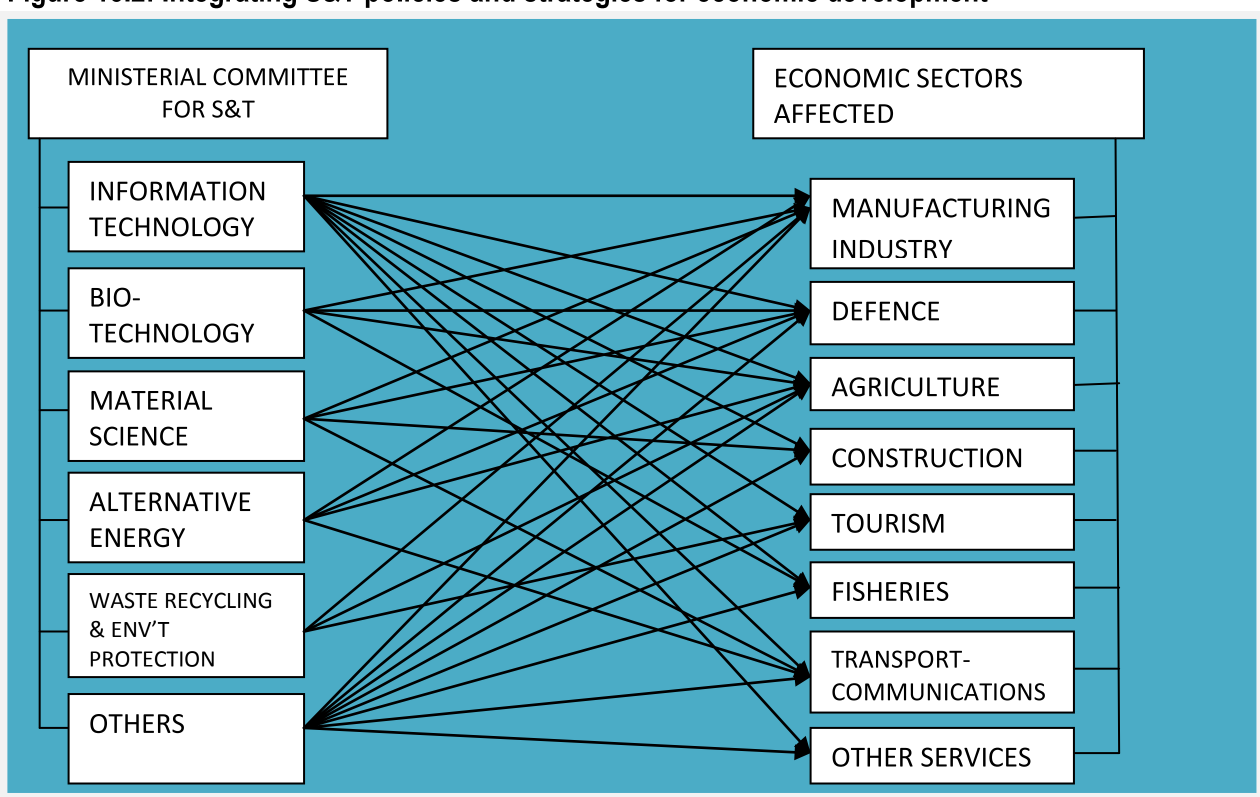
The place of the MCST in the government structure could be as shown in Figure 13.1 above. The committee members should be taken not only from the government side but also from the private sector and the scientific community at large. The suggestion is to include Office of the President, Ministry of Finance & Development, Ministry of Trade & Industry, Ministry of Education, Ministry of Health, Ministry of

Tourism, Ministry of Local Government and from the scientific community (University of Asmara, representatives from research institutes, and representatives from Scientists and Scholars in Diaspora). The number should not be more than 15 to make it more versatile and less cumbersome. The chairmanship could be that of the Office of the President and the secretary of the committee could be the Director of Research of the University of Asmara.

Figure 13.2 does give a general framework of how the Ministerial Committee could develop its policies and strategies to help in the accelerated economic development. This is to avoid one of the major problems observed in the SSA countries, the absence of clear S&T policies that are integrated to socio-economic development. Each economic sector identifies critical technologies, which later are integrated into a national science and technology priority list. Then, the MCST will make sure that any research undertaken in the country with own money or with international funding is of the priority list and has a particular mission toward the achievement of the national development objective.

With regard to industrial technology, at least to begin with, a unit within the University of Asmara College of Engineering or a new autonomous technology institute need be established. This should be done in partnership with the private sector where ideas of product adaptation and innovation of industrial technology could be tested, improved and diffused quickly. The country has to go a long way to build a national innovation system where the university, technical institutions, R&D institutes, industrial technology research institutes, and companies' R&D work co-operatively and in a complementary way to produce and diffuse technology to help build an internationally competitive economy. MCST should immediately try to lay the groundwork for such a development.

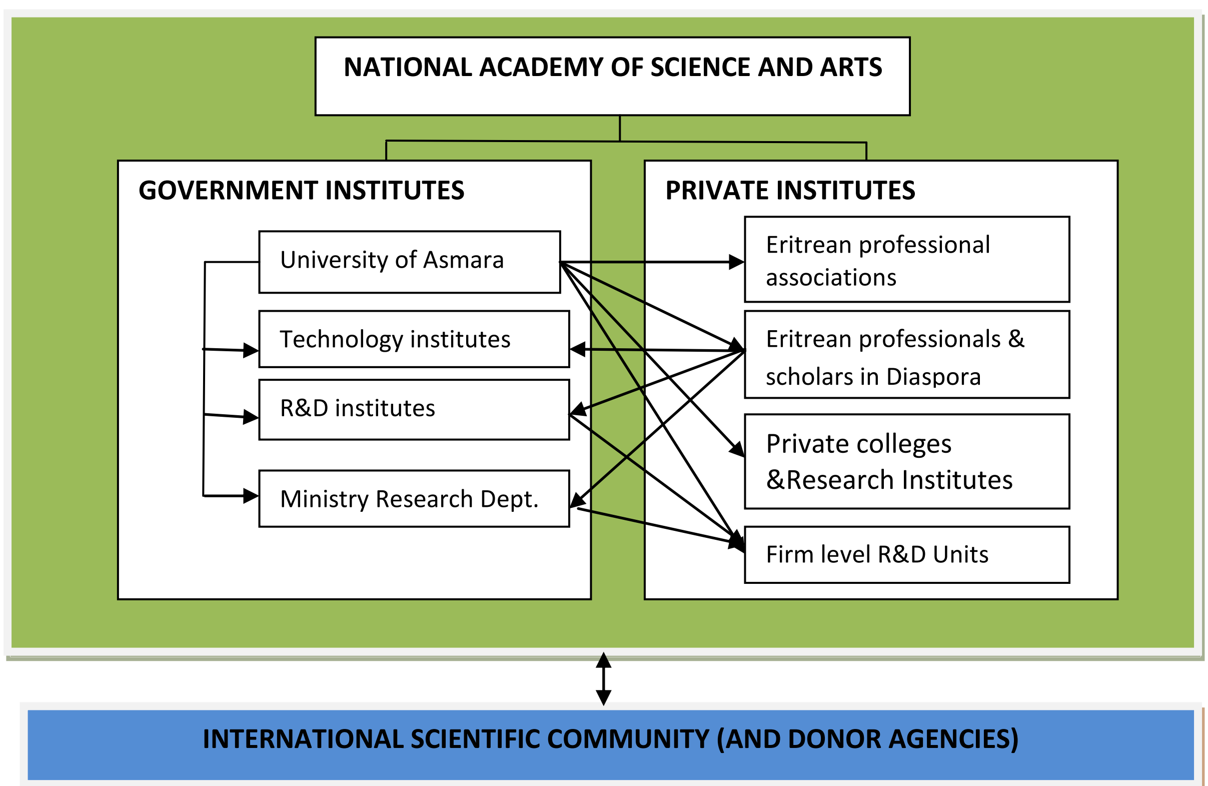
Figure 13.2: Integrating S&T policies and strategies for economic development



Similarly, one other institution that need be established is the 'national academy of science and arts'. As shown in Figure 13.3, Eritrean scholars and professionals in the Diaspora could play a very important role and could get a channel through which they could contribute in the development of S&T of the country. It is possible to start with existing small number of institutes and progressively builds it as a full-fledged science and arts academy. This is something that NIEs of Asia in particular have effectively used.

Clear S&T policies where the national priorities are set are very important. Particularly the place of IT need be spelled out. This is a job the MCST could do. Therefore, ITPAC could become the ministerial committee with broader mandate to include all S&T policies and not only IT policies, as is it is today. A national policy is required to ensure the harmonious implementation and operation of information resources, services and systems throughout the society. Co-ordination and compatibility of the overall national information system is very important. Better complementary and compatible legislation concerning the provision of information is very desirable. Better responsiveness to the implications of the IT and more effective participation in regional and international information systems and services is extremely desirable (Montvilloff, 1990). It is what MCST should aim to achieve through ECB.

Figure 13.3: How a National Academy of Science and Arts can be organized



The point we have tried to make is that Eritrea need to establish S&T policy-making body to direct and co-ordinate the development of science and technology for a sound industrial technology base. We have called this body MCST and have suggested its place and in the government structure and its composition. In the next section, we will discuss computer board to be established under the MCST.

13.4 The future of IT in Eritrea

There is no question that IT in Eritrea is at its infancy. But there is an encouraging sign of relatively quick learning in the field thanks to a small number of computing and communications business firms, mostly from the Eritreans coming back from abroad. On the side of the Government the learning is also there because office computerisation is encouraged but it needs to be more systematic than has been in the past. The regulatory body is also moving slowly. Recently a new Proclamation No. 102/1998 has been enacted on March 1998 to invest the power of regulating the industry of communications to the Department of Communications. The private sector is ahead of the government and is pushing for such regulations to be introduced as soon as possible for they want to be in Internet services business. Some e-mail services are already introduced in the country but full Internet services are not there. Only very recently, in August 1999, the go ahead for internet development was given.

Taking for granted that Eritrea will be connected to Internet by the end of the year, the debate should focus more on how best to exploit the opportunities offered by this revolutionising tool. Eritrea is becoming a market driven economy. The joint venture attempt in the field of telecommunications between Daewoo and the Government of Eritrea is taken as a clear indication of fast progress sought in communications infrastructure development. This knowhow and capital injection could accelerate the development of the country by laying down a modern digital information and communication infrastructure for the country.

A good Information and communications infrastructure could be used as the basis for development of many 'valued added services' such as Internet. Here, it is very important to mention, for reasons of sustainability, which the private sector must be given the necessary incentives to push it to invest and to grow nationally and to compete in the region as well. Wasting more time would only mean killing the opportunity to become regional players. To do so goes perfectly in line with current policies of Eritrea: to become a service hub in the region. It is very important to recall at this juncture that there are already a number of Internet services giving organisations operating in USA or Europe to cater for the Eritrean communities in Diaspora (like Dehai, Asmarino, Visafric and Eritrea.net). These can be encouraged to establish nodes in Eritrea and by so doing we could have a smooth transfer of technology. Or they can join hands with computer businesses already operating in Eritrea such as Tfanus, Ewan Technology Solutions, ETS etc. to work in partnership.

Once this point is reached, the country will be connected to the Global Information Infrastructure. But these are more than a technical issue. It is political, social, cultural, and legal issue as well. It is political because IT requires new structures and these may lead to change in power structure of organisations. Different interest groups will fight some to defend old power structures while others will fight to control more power. This possible conflict of interest should be carefully managed. Appropriate policies and strategies should ensure the development of national information and communications infrastructure that is reliable and accessible to all sections of the society must be developed.

We have said that the process is a social and cultural issue as well because people will be required to change their beliefs and attitudes to go in line with the change brought by the new technologies. Cultural changes take time to happen. A great care must be paid to possible stress of rapid changes in the Eritrean society and the risk of losing one's identity. The wrong conception of western culture adoption as a prerequisite to development should be fought vigorously. Similarly in the legal arena preparations need to be made to create a legal system adequate for an information society. This is because a lot of new legal issues are surfacing as a result of computer crimes and illegalities, and of copyright and patent right issues. Furthermore, the problem of pornography, the issue of subversive materials dissemination, racial hatred and evasion of taxation in the electronic commerce have been among the common problems of information societies and Eritrea from the very beginning need to recognise them and address them properly in the future.

Still another issue is that of information management challenge. Having an information system by itself is not a guarantee of success. The ability to analyse one's specific needs, design and build information systems will become a critical function. The management of information is also critical for to select pertinent information from the flood of information in real time to exploit available opportunities is a competitive advantage. Eritrean firms should develop this capability of getting and giving information to be able to compete internationally. This can be achieved only through education and continuous training. Given the weak technological basis, from which the country is departing, particularly in terms of human resources development, this will be one of the greatest challenges it must face. Highly skilled human resource cannot be produced in short time, Formal education is not enough. People need exposure to practical work before they could accumulate experience and become really productive. Therefore, from the outset education and training should go hand in hand with practical experience. That is, organisations should be encouraged to work with computers and allow their employees to experience working with them, particularly in a networked environment like Internet.

All of what we have just said shows that developing IT infrastructure does not occur over night or spontaneously. Particularly in IT, there are so many competing technologies that one needs to take care such as the issues of compatibility, modularity, future technical support, maintenance and upgrading costs, support services and system security. Experience shows that investment in IT is increasing but returns are at times questioned; a good example of these is the IT 'productivity paradox'. These are the various issues that are forcing countries and organisations to look into better strategies and policies to exploit best this revolutionary and pervasive technology. Particularly from a developing country's point of view like Eritrea where money, skilled manpower, institutional capability, and professional management supply is very scarce. A good national policy would enable force one to look deeply into what is available and what is not and chart the way how the available scarce resources be used optimally to develop a good IT infrastructure and facilitate the achievement of the country's economic and social objectives. Priorities would be set and objectives determined, sometimes making trade-offs among competing national objectives instead of wanting to be everything to everybody which amounts to nothing.

The existing reality in Eritrea, where the private sector is still small and the government plays a big role in every segment of life, leaves no choice but to allow the government to play a catalytic role at the forefront in the diffusion of information technology.

Now, our attention will go to show how the government of Eritrea can play this catalytic role. One way of doing that is by establishing appropriate agencies and institutes to spearhead such development. The National IT Plan would be used as co-ordination tool, but all stakeholders should play an active role in the development of the National IT Plan. Here the example of Singapore can be seen. Singapore, first, established a Ministerial Committee, the Committee on National Computerisation (CNC) which in its turn created a National Computer Board (NCB) as an executive agency to accomplish specific objectives (see chapter 4) and Singapore has emerged as an 'intelligent city'.

The government of Eritrea had made a move towards establishing an agency to spearhead the development of IT in the civil services, EISA (which we have discussed and evaluated in chapter 11.4). It is obvious that EISA is limited to the small services it gives here and there which are mostly technical services in nature like writing some programmes, developing networking systems and giving limited advises to requesting government departments. Departments had to wait for such consulting services, at times, for months before they could get help. Examples of projects in which EISA was involved are the computerisation of BE, CBE, Business License Office all involving systems design consulting services or specific programming activities. Evidently this kind of involvement does not leave room for the preparation of National IT Plan by the two most senior of its staff. To redress this situation we have preferred to restructure EISA starting from the very structure of the government.

We have already suggested earlier that MCST is the policy-making body of S&T (Figure 13.1). In other ways it is replacing ITPAC with wider responsibility while Eritrean Computer Board (ECB) is replacing EISA and becomes a wing of MCST in national IT policies and implementation like the Computer Board of Singapore. MCST could start by commissioning a study in S&T development in Eritrea. IT Strategies and IT Plan could become one of its corner stones. The study could be used as the point of departure. A national conference could be organised where all stakeholders the Ministries, agencies, research institutes, public enterprises, private enterprises and knowledgeable personalities are invited to contribute. MCST could use the recommendations of the conference as the basis of its strategies and plans. It should be able to give clear objectives to ECB to be accomplished within a given timetable. ECB would direct the technical training institutes, higher learning institutes, and the private computer training institutes to share and work co-operatively to develop the required manpower skills in IT. All should complement each other to achieve the IT national human resource development objectives. The private sector should be allowed to participate and should be given the necessary incentives to develop national and international network in the valued added services like Internet, which is the only sustainable long-term option.

We have a very good example of such co-operation in Singapore. The Singapore Telecom is responsible for building and operating the telecommunication infrastructure to make it an international telecommunications node. The Economic Development Board has a mission to develop the country as a global city with a total business orientation. The University of Singapore is responsible for the development of IT professional manpower (see chapter 5). All of these key players work together. Similarly in Eritrea, the Telecommunications Services of Eritrea should work for the development of modern national telecommunications infrastructure. The Macro Policy Office & the Finance and Development Ministry should work for the development of the National Economic Development Plan. The University of Asmara and other public and private institutes should contribute in supplying IT professionals, and the MCST and ECB for the development of the Science and Technology Policies and National IT Plan and Strategies, in line with National Development Plan.

ECB would confine itself to the development of IT in Eritrea. The computerisation of civil service and the promotion and diffusion of IT in the country would fall in its mandate. It may have a unit to make systems analysis and design, and implement projects of computerisation for the civil service only. This in turn can, of course, sub-contract parts of computerisation projects to the private firms, depending on cost-benefit analysis, if private firms can provide better service at a lower cost. The ECB should never be allowed to use its authority to obstruct the development of the private computer services but, on the contrary, should help and assist them to grow and become regional players. The regulation of the IT industry could be jointly done by the Department of Communications in consultation with MCST.

Singapore's experience shows us that within the first five years of its establishment (1980) the NCB was able to establish 23 computer installations with 370 information system professionals. In the country there were already 5,500 IT professionals and four IT education institutions were producing 800 software professionals annually. The industry has grown 10 fold in revenue. But EISA was not equipped to make such kind of transformations, even though, one of the objectives of EISA was 'general manpower development' (Proclamation No. 53/1994, article 6:1, d). First, the very statement of 'general manpower development' is not clear as stated in this document. Does it mean EISA establishing IT training or educational institutes? Or does it mean short term training to upgrade IT professionals? It cannot be the first because that is the mandate of Ministry of Education, in particular that of the higher learning institutes. It could be the second but where are the IT professionals? It is not possible to talk of upgrading of IT professionals when you don't have them. This shows that an important link was missing. IT training/education institutes need first be established.

Developing institutional capability is not equivalent to establishing institutes. For example EISA has been established four years ago but it did not yet develop institutional capability. The ability of delivering quality service, for which a specific organisation was established, as efficiently and effectively as possible, should be at the base of measuring the institutional maturity. Because this is absent in the case of EISA, the conclusion made is that the institution envisioned by the Government, as put in the Proclamation No. 53/1994, did not materialise. It remained a paper work. This could be more visible the moment you take out the private computer business services from the equation of the emerging .small IT industry in the country. Ministries and government agencies are increasingly looking for outside private consultants from within and without the country to get computing services for EISA does not have the capability to satisfy their needs.

The Eritrean IT policies need to define yet what the Internet policy of the government is. There are no guideline how to develop national databases and where should be located. IT in areas with highest socio-economic impact to the country has not been identified. Policies and strategies to increase access to information and communications technologies have not been adopted in particular in education. Policies on IT human resources development have not been developed. For a country that wants to cut all the corners for a quick development and be able to exploit leapfrogging opportunities, it needs quickly a good IT policy and a national IT Plan. The implication of this is to establish ECB (the present EISA) quickly and strengthen in terms of sufficient skilled manpower and funds commensurate to its responsibilities. Another important lesson to be learned is that institutional capability cannot mature only by enacting decrees and laws. This is a continuous learning effort in policy making and implementation; of course, nothing can be accomplished without the resources necessary for it. Given Eritrea have had an ample opportunity of learning from other developing countries it has to do much better.

SSA countries have gone through political and economic changes designed to radically alter the operations of their economics (chapter 8). Many of the countries have adopted economic structural adjustment programmes, which have opened their economics to external and internal competitive market forces. These adjustment programmes have been characterised by a relaxation of the foreign exchange regime making it possible for users of IT to import such technology with few, if any, restrictions. The implications of these changes are that overnight, policies to regulate the procurement of computers and other IT products have become redundant. Such regulatory practices are contrary to the spirit of a liberalised economic environment. In Eritrea this was not the case. As a new country established in 1993, Eritrea does not fit this description. From the very beginning it has followed a liberal economic policy. There are not as such foreign exchange restrictions and people are allowed to freely buy and sell hard currencies openly in the market. This liberal policies account for a significant proportion of IT diffusion in the country. The major problems are the inefficient management and operation of the customs office, and the lack of a critical mass of IT professionals.

Therefore, the establishment of MCST and ECB would be a great step forward in the development of a National IT Plan. This would then give the country the desired clear direction in order to exploit the opportunities offered by this revolutionary technology. It helps in making Eritrea a service-hub in the region. In the next section, we will expand the idea of how Eritrea could leapfrog using IT as a tool for socio-economic development.

Computer networks and possibilities of leapfrogging

Computers are coming to Eritrea but they are mainly used as standalone workstations and not as integrated and networked systems. We know that there are opportunities for technology blending offered particularly for developing countries, which often have small-scale production by small firms in traditional 'low-tech' industries (Antonelli, 1991). Eritrea does have this opportunity. It can develop advanced telecommunications infrastructure, which induces organisational innovations and acts as a powerful factor in economic growth particularly in service industry. In this section we will argue that significant leapfrogging is possible for Eritrea to achieve in service sector in particular.

The national development objectives of Eritrea wants, in short, to make the country "modern, technologically advanced and internationally competitive economy within the next two decades" (Macro Policy, p.l0). This national objective seems to be over ambitious in terms of time frame it has proposed. We read also, among the objectives, that the national development effort will be directed to the realisation of "Developed capital and knowledge intensive and export-oriented industries and services...a competitive international financial centre...." And under the S&T Policy, the objective is said to be "to keep Eritrea abreast of developments in production, transport and service technologies in order to assure an upgraded and modern economic system that is competitive in the world." (p. 37).To achieve all of these national objectives a real leapfrogging is required.

In the Eritrean situation, what does leapfrogging mean? Can it mean the leapfrogging of technological leaders as suppliers of advanced technologies? That is not realistic. Therefore, it is correct to use the word in the right context of IT use as a basic infrastructure of economic development of the country. That is, if Eritrea is able to develop a modern telecommunications and information infrastructure and this is used as the basis for its economic development to create an internationally competitive industry that is considered enough as a real leapfrogging. Particularly, if we see this with the possibility of enabling the country to become competitive in the market of the Horn Region, it is a great leap forward. But Eritrea should go beyond the data processing to reduce clerical costs. It is a time of the second era of information technology: the rise of a new open, networked enterprise, which is a new paradigm shift in information technology (Tapscott and Caston, 1993). Therefore, Eritrea has the opportunity to directly bypass the old technology of isolated systems based on outmoded host computers, to the microprocessor-based open, networked and integrated systems. To do this, a number of possible leapfrogging can be suggested as follows:

1. There is the possibility of building from scratch the telecommunication infrastructure of the country based on the digital switching system. In fact, what is already available is mostly digital.
2. There is possibility of building a computer networked trade (TradeNet) parallel with a national network of warehousing and depots in the six regions of the country. This to work efficiently needs the transport industry integrated with it. A smooth flow of goods and services could be possible, Electronic data interchange (EDI) would be an enabling technology whereby a broad array of business and trade documents employing strictly defined industry standards, purchase orders,

shipping notices, bill of lading, import/export approval documents, and other invoices could be exchanged electronically improving the overall industry' s productivity.

3. There is a possibility of building a health network (HealthNet) that works across the nation where the main nodes are the six regional health service centres. This could enable the remote clinics and health .service stations to get expert support from the Referral Hospitals and Health Research Institutions and in their turn could feed the central databases of information at the local level. This could make a real time co-operation and it would mean a great leap forward in rural health services. The management of Health Services of the country would also benefit greatly from it in their policy decision making.
4. There is the possibility of building a national education and research network (EduNet). This could qualitatively enhance the education system of the country and the scientists could share ideas and join hands in multidisciplinary research activities. Distance education could develop easily.
5. There is the possibility of building a network for the tourism industry (TourNet) by linking all hotels and restaurants and tour companies, car rentals, and travel agencies across the country.

These networks assume a great change in the structure of the industry for which they are meant. If we take the case of a national trade network, the stakeholders would be the financial institutions, the shipping and forwarding companies, import and export firms, transport companies, and the government departments such as the land transport, maritime transport, civil aviation, customs office, commercial banks, insurance companies and the Bank of Eritrea. All of these should work together to make possible the TradeNet to work. Physical changes required could be the building of warehousing facilities in the six regions with sub-region ramifications, customs offices, bank branches, shipping and forwarding offices, and others in close proximity so that the customers are served in a kind of one shopping stop. This entails a new way of organising and managing business and public services as well. The command-and-control hierarchy system of organising has to be replaced by a multi-layered hierarchy to flatter networks or relatively autonomous entities with self-managed, responsive and entrepreneurial work teams as key organisational entity all working in the environment of expanded network that includes suppliers and customers (Tapscott and Caston, ibid).

Information could be organised in a way that incoming imported goods are packaged/unpackaged by regional depots from where they originate (or destined). Then, they could be directly loaded from ships to trucks (or vice versa) at the ports to destination without any need of wasting time to unload and unpack them for reasons of customs office, which could be carried out at the final destination depot. This could tremendously improve the flow of goods. Parallel to these physical flows of goods, the flow of information and documentation could take place through the TradeNet. The government department responsible for approval of import/export of goods would receive applications electronically and processes and forwards them on a real time basis. The same could take place about financial transactions of payment of duties and taxes and other service charges among business people. If these physical and informational flow are well synchronised, the leapfrogging we were talking about could happen.

The same can be done for the HealthNet, EduNet and TourNet. This entails that a national information and communications infrastructure is a priority where the significant investment in telecommunications and computer networking is required. If this is done, the country will have done a lot of leapfrogging to get it connected to the global economy. Again, this could be only an enabling environment. Political, economic and social stability is very basic ingredients for such scientific and technological advances.

If this is to occur in the coming two decades, then, government policies, explicit or implicit policy decision on S&T issues in Eritrea, should be consistent. By 'consistency', we refer to whether the policy is consistent with the long-term socio-economic development objectives of the country or whether it is consistent with existing policies as well as consistent over time. Similarly, it means whether it is consistent with the 'export-oriented open and free market-led economic system', or whether it is consistent with the country-specific social and cultural environment. It should also be adaptable. 'Adaptability' refers to the possibilities of the policy to evolve and change in response to changes in domestic and international factors. At last, good policies are easy to implement. 'implementable' policies are those realistic to put into action given the resources available to the country at a given time.

Eritrea wants to be part of the new global economic order. The dominant players in this new global economic order are the 'networked societies'. Eritrea needs to develop an ability to connect with this new order. That means, it has to leapfrog to become a networked society itself. Hence, it is consistent with its long-tem socio-economic development objectives. Besides, it is consistent with the needs of an export-oriented open market led by the private sector, which Eritrea wants to become. This desire to connect with the new economic order shows that the country is adapting to new changes in the world. But is it not over ambitious?

Global connectivity

From where will the investment come to implement these radical changes that this leapfrogging requires? This is not a year or two-year journey. But in coming few decades it is possible. The entire plan should be implemented in phases where the initial stage will be dominated by know-how development. Since learning by doing/using is central to the transfer of IT, small units can be immediately established in all sectors knowing exactly where they are headed. For example the joint venture with an international telecommunications carrier is a good start. The World Bank and other international agencies can provide funds for specific projects, and the Eritrean government should allocate a budget for the development of S&T in general and IT in particular to sustain its development (it is consistent with self-reliance philosophy of the country). May be the most challenging factor is going to be the development of a management cadre to lead this change.

One of the cornerstones of technological capability development is skilled manpower. The Eritrean skilled manpower resources will be assessed against the demand that each policy on S&T does make. The difference between demand and supply of skills gives us the gap that exists between them. The current assessment of the number and experience of skilled professionals and scientists in the country is poor. The bold initiative of the government in partnership with the World Bank, a US$60 million project for highly skilled manpower development, is a good start. But it needs a very good national human resource development plan.

Developing industrial technological capability requires a lot of institutional support. The institutional capability in Eritrea is poor and there is institutional gap critical for the industrial technology development. That is, educational and training institutions, research institutes, the university, funding institutions, and the private sector and their interrelationships and cooperation gives a picture of a poor institutional infrastructure, though rapidly changing. The degree of trust and co-operation among government and private institutions, and the industrial networking has to grow considerably. IT is diffusing quite rapidly in all sectors but the manufacturing industry is lagging behind. The private computer business is the backbone of the diffusion of IT by providing the support and the government civil services are the biggest users of computing which are deployed in the old fashion of data processing and office automation. Therefore, IT should be carefully designed and implemented to improve the institutional capabilities of the country by increasing networking and information flow among them.

Developing countries can always learn from each other's experience. This is a research on IT development in a special country, a new country in the African continent created in the early 1990s. It is a unique experience from different angles. This country has emerged in the post cold war and the time of globalisation as well as time of the emergence of the three trading blocks in the world. The leadership of the country has emerged from a long war of liberation schooled in the socialist philosophy and an experience of self-reliance in the real sense. This leadership has a very strong belief in the country's own resources for development. There is a st1'ong sense of self-confidence which are quite unique in the continent, an apparent contradiction given the country is small in size and one of the least developed countries in the world. The motto is "we want to be the masters of our own destiny!" "No to aid, yes to partnership!" "Help is welcome as long as it does help to build our own capabilities to manage our own socio-economic system!" This is why Eritrea is shunning getting large loans from international community and trying to mobilise its own resources as much as possible. Too much of NGO are not considered help but a hindrance to the real development of a country's capabilities.

It is within this socio-economic and political environment, described above, that S&T policies are to be considered. The last four years were very hectic years to get the government's institutional capabilities established and reorganised. The Macro Policy of the country, where the vision and the strategies of the country were defined, was framed in 1994. The National Economic Policy Framework and Program (NEPFP) was framed in 1998, and the National Human Resources Development Plan is in the process of making. It is time to give due attention to S&T policies. The present policy of having S&T research and development decentralised to the ministries, who have been empowered to take the responsibilities of conducting research and training in the respective sectors, does have long-term side effects of possible fragmentation and the pulling in different directions. On the other hand, these research departments for obvious reasons of lack of funds and skilled manpower are not yet functional in many ministries.

Some glimpse of hope is there. The computing and communications industry is emerging and growing. Many small private companies are emerging. This are mostly owned and managed by Eritreans coming back from Diaspora with acquired new skills which has been the blessing to this emerging new industry. Already there is keen competition for the small emerging market. Some of them are even looking forward to becoming regional players as training institutes or services givers. Others are also thinking of establishing computer assembly plants if the Customs Office stops its bias against computer component parts import as import tax for a whole computer is smaller than the tax for its parts, really discouraging to the emergence of the assembly industry. Eritrea can use these new trends to start build its IT infrastructure on which to base its future socio-economic development but the government should be quick in identifying and eliminating regulatory and administrative inefficiencies stumbling blocks.

Therefore, the Government should proactively provide policies to guide the progressive integration of all networks to create a national information network. This proactive thinking and planning should be used to improve productivity, quality of products and/or services, efficiency in the work place, and competitiveness in the international market place. The links between IT and the different sectors of the economy must be analysed and understood at the planning process. This is why IT Plan should be an integral part of the National Economic Development Plan. In Eritrea this means to develop an IT infrastructure capable of enabling the country in becoming a service-hub in the region as planned in its Macro Policy. The MCST and ECB suggested earlier are exactly mean[to achieve that.

13.5 Institutional capability

This Government has inherited not much in terms of political and public administration institutions from the Ethiopian government. The only thing found in the country after Liberation was some 42 nationalised ailing public enterprises plus the public utilities and some provincial administrative offices. From the governmental institutional capacity point of view, the country had to start from scratch. After 7 years, in a recent interview with African Business, the Minister of Finance and Development replying to a question that 'Eritrea has no national account as yet, and no national budget' said: "We have been working on that for some time. The transparency issue does not worry us, because we have always stressed that all institutions, not just the public sector, must produce audited accounts. We have not achieved the position of annual budget, but all expenditure are approved and have ceilings" (African Business, April 1998, p.20). A sign the country is still struggling to develop its Government institutions. It is possible to say that the Bank of Eritrea as a real institution, as a national bank, has emerged in November 1997 when the Eritrean currency 'Nakfa' was launched to replace the Ethiopian currency 'Birr'. All the Ministries and Agencies are only beginning to take their institutional shape slowly. The country has to learn a lot and it is learning quickly to build its institutional capabilities.

From the perspective of the present research, S&T institutions are the main focus. These are very central to the development and diffusion of relevant S&T for the development of the country. The Eritrean Macro Policy, under S&T policy, talks about the 'establishment of a national institution to gather information about existing and emergent technologies worldwide, evaluate their appropriateness for Eritrean conditions, and make this fund of knowledge available to the public and private sectors' (p. 37). Now after four years, where is such an institution? How do we to establish it? May be, this are questions the country has forgotten to ask itself. In the same place, it is possible to read that 'research and development efforts in selected sectors' will be promoted. Who is the institution that determines the sectors to be given priority and selects the research projects, gives the needed fund, and makes sure that the funds are properly utilised? The present situation of establishing Research & Training units in every Ministry by itself cannot ensure that appropriate, relevant and timely research are conducted and effectively managed. A country that wants 'to keep abreast of developments in production, transport and service technologies in order to assure an upgraded and modern economic system that is competitive in the world' (p.37) cannot afford to relegate to the periphery the development of such institutions. There could be no excuses of lack of funds and skilled manpower for their embryonic structures should be there, to start with, and be allowed to organically grow, if the political will is really there. For example, the ECB we have proposed will start as a cell. But it should be allowed to organically grow with the demand of its services to become a mature institution to guide the development of IT industry and services in the country.

Similarly the legal institutions, economic institutions, and the social and cultural institutions should have at least a cell like of soundly grounded units that can grow into mature institutions. Only if such political, legal, economic, social and cultural, and technological environment is conducive sound S&T policies, appropriate National IT Plan and a good human resource management can thrive. This macro level picture should be complemented by micro environment where the Government institutions, public enterprises, private enterprises and the social and cultural institutions in the country are able to create a network and develop a work-culture of co-operation and mutual assistance. The activities at macro and micro-level together should put the country in the position of learning and mastering the use and adaptation of new technologies and their fast diffusion in the country. National information and communication network is a key factor in keeping all institutions together like glue. Computer networks and Internet would be the gate to global integration and could play a central role of the development of S&T and the gate through which information on national and international markets are acquired.

13.6 Human capital formation

Human resource is a very critical resource in the development of countries. The Government needs to address quickly policy issues related to human resource. The objective of producing 'a population equipped with the necessary skills, knowledge and culture for a self-reliant modern economy' (Macro Policy, 1994) does require a lot of additional technical/vocational and higher learning institutions than presently available in Eritrea.

When Singapore decided that IT was strategic technology for the country in 1980, the country had only 850 IT professionals. Then, the National IT Plan was adopted and by the end of 1990 the poof increased to over 10,000. By the close of the century, the number is expected to be more than 25,000 IT professionals. Now in Eritrea, the researcher estimate is about 300 IT professionals, excluding the computer operators. This poof is made up of Eritreans coming from the Diaspora and establishing small computer/communications business services, some 30 of them, and those young people produced in the private computer schools in the last five years. If Eritrea is to reach at the level Singapore is now in 20 years from now, it should be able to produce not less than 1500 IT professionals a year. This may look like an impossible target to achieve given that the University of Asmara annual total production is about 400 graduates in all fields, none of which is in IT. Very few are being sent to train abroad. It is not possible to say that IT is a priority list in the human resource development of the country.

The vision of the country is to become a truly modern and competitive country in the coming 20 years, but specifically IT, as a pervasive technology and as a necessary infrastructure of the future, is not getting adequate attention. It is here that an adequate policy of human resource development is of paramount importance. The University of Asmara should give priority to IT education and training at degree level and a selected private computer schools could be given by the government incentives to open diploma level training programmes in programming, computer networking, hardware and software maintenance.

All the different MIS departments in every organisation in the country play a major role since they are responsible for the day to day operation and management of all computing resources. The quality and experience of IT managers is important factor. Because of lack of skilled IT manpower in the country, in general the IT management in the country is poor with very few exceptions. A good example to the inefficiency existing in the country can be observed from how poorly computers are utilised. Most organisations are still using them mainly for word-processing. It is possible to see computers idle in the offices of the managers while employees in information intensive activities are still working manually such statistics or accounting departments.

Therefore, a great deal of investment is required for IT skills development particularly that of systems analysts and designers, programmers, database administrators, computer network experts, and computer hardware technicians. Motivated people are very productive. Having skilled and motivated people is at the heart of good IT management. Given that the 2lst century is for the networked society, the country need to address the critical shortage of IT skills and should be able to create a small critical mass at least in the coming 5 years.

13.7 Concluding remarks

Eritrea, to put its socio-economic development on a sound basis, needs to embark immediately on building its S&T infrastructure. It needs to determine the technologies most pertinent to its own needs that at the same time enable it to get connected to the new global economic order. If different technologies are not evaluated in relation of likely contributions to the socio-economic development of the country, proper resource allocation will become very difficult. Thus, an institutional body to determine technological development priorities is required for a capable S&T policy-making body would not be difficult to identify the centrality of IT to the development of a modern economy. IT human resource development would get its right place. One thing is for sure, the Eritrean service industry would greatly benefit from IT and trade, tourism, financial sector, civil services, health services and education would really leapfrog if proper networking is developed, which requires radical changes in management and organisation resource. It is time to look at the national infrastructure development in an integrated way where transport and communications are designed together with trade, tourism, the financial sector and civil services so that the flow of goods and services moves parallel with the flow of information in a real time. This is definitely the way to greater regional and international competitiveness.

The advantage for Eritrea is that it is starting afresh with zero debt. It can use aid money and loans to build its national infrastructure and for the human capital formation. Eritrea can acquire and assimilate mature but modern technologies and later with experience improve and adapt them to its particular needs.

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14. General Conclusions

This research was meant to study two questions; (1) What is the state of S&T policy and management in developing countries including Eritrea? What is the state of IT in these countries? (2) How can Eritrea exploit best the opportunity offered by IT for its socioeconomic development based on the experience of other developing countries? It did so by making a comprehensive literature search to answer the first question related to NIEs and SSA countries (chapters 4-9). With regard to the case of Eritrea, it used primary data collection methods like surveys and in-depth interviews. It dealt with the first question on Eritrea in chapters 10-12 and the second study question is dealt with in chapter 13. Now, the major findings are summarised below:

14.1 Newly Industrialised Economies

In this research, the NIEs included in the sample are South Korea, Taiwan, Singapore, and Hong Kong in the Southeast Asia and Brazil and India from Latin America and South Asia. The most important lessons on S&T development are summarised below.

Answers to study question number 1: the NIE

The conclusion we have reached is that there is not a single best strategy for quick development of science and technology. Protection against imports and selective exclusion of foreign investment, accompanied by upgrading of skills, huge investments in R&D and sponsoring of giant corporations to internalise various markets to cope with international competition, was the experience of South Korea. Singapore relied entirely on imported technology but intervened selectively to induce investors to move up the technological scale and provided educated and trained work force. Brazil has set up large public enterprises and restricted foreign entry in certain sectors to protect indigenous learning. India excluded MNCs in much of manufacturing, but suffered technological lags and inefficiency as a result of its trade and industrial policies. It is very important to keep in mind that these countries have not always followed the same policies in every sector consistently over time. Particularly during the 1990s, the trend in globalisation has pushed Brazil and India to open up and liberalise their economies.

One important lesson in the industrial technology development of the developing countries is to reverse the usual sequence of developing technological capability, which is emergence consolidation-maturity to acquisition-assimilation-improvement (or innovation-investment production to production-investment-innovation). The benefit from transfer of foreign technology depends less on the method of transfer, but more on how the method is implemented. NIEs, with some exceptions, have used the acquisition-assimilation improvement approach in the development of their S&T. In particular the industrial technology development of the East Asian Tigers is considered a great success. These countries have demonstrated that appropriate technology assessment and choice are very crucial for some technologies open more possibilities than others are do. For example, the experience of the four Tigers in focusing on electronics industry and IT infrastructure development proved to be successful. IT is a pervasive technology and is a necessary infrastructure for the development of all the economic sectors. Countries like Singapore have made it one of the backbones of their economies and have enjoyed a great leap forward in joining the global information society.

Governments do play a very important role in the technological development by inducing choices of techniques that are socially more appropriate, fostering imports on the best possible terms, and stimulating the development of specialised technological agents such as industrial parks, science parks and scientific and technological information centres. The high priority given to human capital formation in East Asian countries is considered to be one of the pillars of their economic success story. That proves that highly skilled human power is the basis of any scientific and technological development. Therefore, appropriate national human resource management and investment in human capital formation are priority issues for socio-economic development to take place. It is the most important infrastructure for future socio-economic and technological development of any country.

Governments can make sure their policies do not militate one against the other. While the Tigers showed greater integration of their S&T policies with their national development plans, the Indian S&T development, and to a lesser degree that of Brazil, were not well integrated to their economic development plan, which explains their relative poor performance. The 'light-industry' as opposed to the 'heavy-industry' approach followed by the East Asian Tigers has proved to be more sustainable" While the emphasis on heavy industry by India was less successful and less sustainable. It is not possible to say that India and Brazil were more interventionists than the Tigers, In fact, The East Asian countries (less so Hong Kong) all showed strong governments very active in the guiding of their economies. But the import-substitution policies and emphasis on public enterprises of India and Brazil were less effective than the export-oriented and private enterprise led policies of the Tigers, which always were steered by strong government hands. The most plausible explanation of the difference in the degree of success lies in the quality of policy intervention and political commitment to implement it.

14.2 SSA countries

Answers to study question number 1: the SSA countries

Almost four decades have passed since most of SSA countries got independence but yet no much have been achieved in the field of S&T. These countries are more dependent than ever from the developed countries for their capital goods needs. This does not mean that African countries have not tried to follow the footsteps of the developed countries by trying to copy and implant industrial complexes but failed dismally. Still SSA countries depend on primary goods for their foreign exchange. The development-related debt of industrial development of the 1960s and 1970s were not successful but led to heavy debt as a result. Their industrial policies have failed. The colonial legacies, the making of colonies the source of primary goods and markets of manufactured goods, were difficult to remove. On the other hand, the developed world is interested in keeping the advantage by making access to finance and technology very difficult through various price mechanisms and conditions.

A strong political will and determination to succeed in the process of socio-economic development is a clear advantage. The belief in one's own resources, self-reliance, as the most significant determinant of development, is what seems to be missing most in SSA countries. This component is very important because it pushes the country to learn and learn quickly to avoid from being left at the margin and get quickly connected to the global economy. But at every turn, SSA countries are facing very costly political instabilities. There are too many wars, some internal others with neighbours. The whole continent is also very susceptible to external interference. Peace is the only foundation on which all development activities can take place but, so far, this continent has not been fortunate to have. Of course, all of this has also to do with the quality of leadership these countries have. There are too many dictators and corrupt government institutions. The continent needs more 'Mandela's' to free itself from corruption and injustice.

SSA countries S&T policies were not effective because of lack of resources, institutional problems, and mismanagement. Corrupt politicians' only interest was keeping their power base at any cost where the development issue was not a priority, intellectuals felt less safe and brain drain was a constant problem. The cold war situation also had an impact because for reasons of strategic interests of the superpowers. The Western and Eastern blocks were helping otherwise corrupt governments to keep their power. This was continually denying the legitimate aspirations of people to get rid of corruption and mismanagement, thus delaying the chance to focus on real development issues.

In SSA countries skilled manpower and institutional capability have been found to be the most critical factors but in short supply. But these are required at every step in the development of S&T and in particular of information technology. Policy making itself was hampered by the absence of those two critical factors. Therefore, any developing country embarking towards S&T development in general and IT in particular, should first focus on required human resources development and the creation of appropriate institutions to support and sustain such development.

IT policy or National IT Plans in Sub-Saharan countries of Africa is at its initial stage. The globalisation trend is pushing every country, including the less developed countries, to get connected to the international information and communications infrastructure. There is a growing awareness of the importance and necessity of information technology for socioeconomic development of SSA countries. As always, African countries are disadvantaged from the lack of capital investment, skilled manpower and institutional capabilities. Some countries are making significant progress in the development of telecommunications infrastructure development. But even though the industry has potential to grow it is at its infancy. A strong political will and a good dose of financial injection coupled with the right human resources development could accelerate the development of the industry and things could be changed in the coming years.

14.3 Eritrea

Answers to study question number 1: What is the state of S&T in Eritrea?

Eritrea is the youngest country in Africa, which got independence in 1993. It has experienced rapid industrialisation during 1940-1960, which was destroyed during the 30-years war of liberation that ended in l99l. But the war of liberation did not bring only destruction but also developed self-reliance practice, which has become deeply ingrained in the Eritrean life. Now the country is trying to build its infrastructures and create an open market economy structure and measures are taken to attract FDI through better policy environment, a stable political and social environment with corruption-free and efficient government institutions.

Eritrea is determined to leapfrog many intermediary stages of technological development to catch up in the process of development. Heavy investment is being made in new machinery and technologies, particularly in the construction industry and the energy sector. For example, local public and private companies are making the road construction activities, i.e. by internal resources. It is a very good example of self-reliance and learning of new techniques and work methods which is building the technological capability of construction industry. There are also foreign construction companies in the country such as the Keangnam

Enterprises from South Korea (the biggest). There are also Italian and American firms. This is helping in the transfer of new technology and skills.

Drip-irrigation system, a new technology for the country, is being introduced, in the agricultural sector. The seaports are being modernised to make them more competitive in the legion. Importance of research for future development is recognised but S&T policies are not yet fully developed. Mature scientific and technological institutions are absent. The Research & Training departments established in all ministries lack financial resources and particularly suffer from skilled manpower shortage. The only national university, University of Asmara, does not have a research base nor identified research priorities. It was a teaching oriented university but now it is taking the first steps to develop its research wing.

There are opportunities for the country if it uses IT, which this research is all about, to enhance its learning and its capability to manage the national resources through the effective use and diffusion of this technology. The country's ability to gain regional and international competitiveness as an international player integrated in the global economy in the coming 20-30 years can only be achieved if Eritrea immediately embarks on human capital formation and IT infrastructure development. But the capability of effectively selecting, introducing and using of IT in some key sectors such as public administration, education and training, health, finance, transport, tourism, and trade in general are of immediate necessity.

In Eritrea, the private sector is not, at this stage, capable of undertaking research activities or responsibility. The government is responsible for education and training and the private sector has an insignificant role so far. Even the few "big" enterprises are in the hands of the government. So far all the banks and insurance firms are of the government, even though, deregulation will permit foreign banks and insurance companies to operate in Eritrea. Moreover, the development of the necessary infrastructures is in the hand of the government. The construction and maintenance of highways and roads is under the Ministry of Public Works. The seaport administration, the airports are all in the hands of the government. Public utility production like the electricity and water supply are also in the hands of the government and municipalities. The private .sector is mainly in the retail, wholesale, catering, transport, leather, furniture and household appliances, construction, mechanical services, bakeries, and small agri-businesses and other services. All of these are small family business type; of course, there is also the "informal sector".

Therefore, the role of the Eritrean government, at this juncture of history, is very big and cannot delegate it to any other body. Till the time a critical mass of bigger and capable private sector is created, the government has to assume a big direct involvement in the economy. Therefore, policies can be of great help to determine where the country wants to go and how to do it. The government is the only one at this time that can create an environment for the right technology choices, transfer and management. But these policies should spell out clearly the present and future roles of both the government and the private sector with regard to technology choice and diffusion. The government should be there not to replace the private sector but to help it grow and assume its full role in the economy and the society as a whole.

14.3.1 IT in Eritrea

Answers to study question 2: How Eritrea can best exploit-leapfrogging opportunities offered by IT?

IT industry, in the last five years, has made considerable progress and is catching up fast relative to the region. Private investment in computing services is increasing because Eritreans from the Diaspora are coming back and establishing their own companies. And the Telecommunications Services of Eritrea (TSE) has given clear indication of willing to modernise and transform itself through joint venture agreement with foreign carriers. The expectation is that telecommunications infrastructure in the country is going to grow fast in the coming few years. The government seems to have rightly recognised the strategic importance for economic development of this sector. The Department of Communications has been mandated with regulatory authority over the communications industry and is moving in the right direction in the promotion and development of telecommunications.

The Government has established an information agency, EISA, to develop, advise and implement IT policies and strategies, particularly for the civil services and the public enterprises. But this agency does not have the required human and financial resources commensurate to its mandate, therefore, did not contribute much in the development of IT use and diffusion in the country.

The major stumbling block for the technological development of the country, without doubt, is the lack of skilled human resources. The Government has recognised the human capital formation as a priority area. It has recently got a loan from the World Bank, $60 million, for the development of highly skilled manpower.

Eritrea did not yet develop the information and communication infrastructure plan to really exploit it for its economic development. Given the country's short number of years of existence, it is not reasonable to expect more. But there are opportunities to leapfrogging in IT industry, particularly in the use of it as an infrastructure for greater economic development as well as becoming a major economic player as a trade and service-hub in the greater Horn of Africa region.

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15. Recommendations

15.1. General

- S&T policy-making body should be established as a MCST (ministerial committee for science and technology) to plan and co-ordinate all S&T research effort of the country.
- S & T policies should be specific enough to guide each economic sector for the right technology choice and transfer and operation to enable to create competitive goods and services for local and international markets.
- IT should be recognised as a critical technology in the economic development of the country by transforming EISA as computer board under the MCST. But it should be given all the required attention to develop its institutional capability to really make felt its presence in the country and make the difference.
- National IT Plan should be produced without delay. It would enable the country to build its national information and communications infrastructures for an effective socioeconomic development. It would help the country in exploiting the opportunities offered by its strategic location as a gateway for Europe, Middle East, Asia, as well as to East, Central and Southern Africa in the development of regional information and communications infrastructures. These opportunities are there if the country takes immediate action before others do.
- S&T policies and IT Plan should be linked to the National Economic Development of the country otherwise technological capabilities that do not make major contribution to the national economic and social development may take considerable resources at the expense of those that really matter.
- Policies should be the product of participation of all stakeholders and not a dictation from some government offices to be of great benefit to the development of the whole country. The Government should always make sure that policies are used as a means of mobilising and effective resource utilisation and not as an undesirable interference and hindrance to the private sector development.
- IT policies should be specific about the priority areas of development within the IT industry. For example, computer assembly lines should be allowed to flourish and lay the groundwork for software industry to develop.
- S&T policies should strengthen the ability to select, acquire and adapt industrial technology to economic and social conditions in Eritrea, including evaluating the technical, economic, commercial and legal aspects of industrial technology-transfer agreements and contracts:

15.2 Sector specific policies

- MCST would need to include all sectors in the S&T policies and plans and give an integrated vision of the whole and what is expected from each sector at the same time. The various ministries are currently doing or on the process of organising themselves to do it. These need be brought in line with the national priorities. To mention some of priority areas:

- Introduce selective environmental friendly technologies in agriculture (modern irrigation technologies, water conservation technologies, desalination technologies, animal husbandry, pest control, desertification control, etc);
- Improve specific crop-storage, transport and handling to avoid big post-harvest losses;
- Introduce improved technologies for food processing, preservation, storage and packaging;
- Support the manufacture, repair and maintenance of equipment in the fisheries sector, including helping to set up facilities for fish-processing, preservation and storage and to develop and promote economical designs and construction techniques and materials for making, repairing and maintaining fishing boats;
- Introduce new technologies in marine resources sustainable exploitation and management;
- Introduce new construction techniques and methods;
- Modernise the electro-mechanical industry;
- Introduce and diffuse the information and communications technologies;
- Expand technical and vocational training;
- Expand selectively tertiary education;
- Establish selectively S&T institutions (mission oriented) to nurture researchers and engineering consultants and improve technical capabilities (particularly in generating local technology) of the Eritrean manufacturing industry;
- Manage through appropriate policies the coexistence of modern and traditional productive sectors and big- and small-scale production;
- Develop an information technology industry capable of supporting the needs of regionally competitive financial institutions, trading companies, transport and communications industry, and tourism industry;
- Invest in and promote the development of various kinds of national networks such as TradeNet, EduNet, TourNet, HealthNet, etc.

15.3 IT skills development

- Immediate concerted action should be taken to develop critical IT skills necessary to support the IT industry in the country. Eritreans from the Diaspora are making great contributions by establishing computer services companies and training but it is inadequate to address the highly skilled manpower development. Particularly the development of systems analysts and designers and programmers should be addressed by tertiary institutions like the University of Asmara.
- Private training institutes should be allowed and encouraged to grow to meet all the IT technical skills required by the computer and communications industry. The Government's role should be to create an environment conducive for such development without wanting to do everything by itself. It should also provide standardisation and accreditation services in order to keep high the quality of training given by private institutions.
- Comprehensive and fully integrated programs for preparing industrial trainers and developing local technological and entrepreneurial capacities should be started immediately.
- Multi-purpose and specialised institutions to train people for core industries should be strengthened or established.
- The links for industrial training between the university and factories should be established.
- Local companies to produce teaching and training materials, training videos, kits and manuals should be established to strengthen the human capital formation of the country.

- Training at the national, sub-regional and regional levels in the development, acquisition, adaptation and transfer of technology, including evaluation and negotiation of technology contracts should be established.
- Eritrea should promote co-operation between enterprises, for example, in production, technical and industrial training, information, investment, and research and development.

15.4 Institutional capability development

- ECB as a catalyst of IT development could play a major role in the diffusion of IT in the civil services in particular and in the country in general, if its institutional capability is fully developed. It needs highly skilled manpower, adequate facilities, and adequate budget. It should be able to work in partnership with the private sector and not in competition. They are not mutually exclusive elements in the IT development equation.
- The Department of Communications, as a regulator body of the communications industry, should develop its institutional capabilities to be able to do the job entrusted to it adequately. A critical shortage of highly skilled manpower is visible and need be addressed quickly. The regulator possibly should be always ahead of the industry that it regulates. Of course, the Department needs also adequate budget to run properly its activities.
- Privatisation process of the Telecommunications Services of Eritrea is encouraging. The joint venture with a foreign experienced company should be carefully managed. Its long-term objectives should remain that of developing and efficiently operating an internationally competitive information and communication infrastructure to support the economic development of the country.

1.5.5 Networking and proper work culture

- The weak S&T institutional capability of the country can be said is at the basis of the non-existing network among the S&T policy making and implementing bodies such as the government, the university, and the industry in general. Particularly, the university does not have any connection with the private sector in the process of S&T development in the country. Therefore, a culture of co-operation among these various government, non-government and private organisations should be established. A good network among these institutions is very critical and need be quickly addressed.
- A work-culture of co-operation should be promoted to diffuse quickly new technologies. This should be allowed to mature to the extent of creating a tacit norm whereby government departments and agencies (government institutions), public enterprises, private enterprises, NGOs and other social institutions work together in a recognisable pattern of how things get done. In Eritrea the government should play a leading role in the development of an environment where such small and medium sized private enterprises could grow and play their role as agents of scientific and technological diffusion. The various policy instruments could be used to create such an environment.

15.6 Regional and International co-operations

- Eritrea is a member of IGAD, COMESA, and now COMESSA. These three regional institutions are trying to forge a new political and economic relationship among them. A good communications and information infrastructure would greatly strengthen these emerging institutions. Communications networks among these countries is very poor and need be developed and Eritrea should play a constructive role by creating adequate databases for various economic sectors from where its regional partners could get information to strengthen their ties. At the same time it should develop all the necessary expertise to exploit such regional information services that already exist or will emerge in the future.

- There are countless regional and international institutions working in co-operation with each other in various fields of human endeavour such as economy, environment, health, population, culture...etc. Therefore, Eritrea needs to get connected to the international network of information and communications infrastructure soon in order 'to make most of available scientific and technological information for the betterment of its own population. But it should not limit itself at the receiving end. It should quickly develop its own national information databases, as said above, to make it a real partnership in a 'give and take' relationship for many could gain from the unique Eritrean experiences as Eritrea could gain from that of others.
- International, including intra-African, co-operation in industrial training should be promoted. Eritrea should try to make full use of the existing ones.
- Eritrea should work closely with other African countries in the development of technological information base, including setting up national, sub-regional and regional information centres linked to centres outside Africa via the Industrial and Technological Information Bank.
- Eritrea should immediately get linked to technological co-operation within Africa and between Africa and the rest of the world and it should do its part to promote it.

15.7 Future research

- Eritrea should immediately systematically study S&T needs in various sectors, including the best way of transfer of technology in a way that can support the achievement of the national socio-economic development objectives.
- Research is required to establish a better way of organising industrial technology development and diffusion in Eritrea including the development of support services.
- More research is required in Eritrea to document cases of technology adaptation and improvement in the various sectors. This would be of great help to policy makers to design appropriate incentives for in innovators.
- Cases of IT implementation need be documented continuously in Eritrea to help policy analysts to proactively design appropriate strategies in order to fully exploit opportunities offered by IT.
- Eritrea needs to make detailed research to determine the new skills required for its scientific and technological development. This should be one of the bases of the national human resource plan.
- More empirical research in S&T transfer need be conducted in SSA countries in general to improve the poor knowledge base.

Appendices

Appendix 1: Labour and capital productivity as influenced by microelectronics

1. The sectors with the highest rates of growth in the labour productivity are the electronic Industries, and especially the computer industry and the electronic component industry. These are the industries, which make the greatest use of their own technology for design, production, stock control, marketing and management. They are also the only industrial sectors, which show a substantial rise in capital productivity. They are the sectors, which demonstrated the advantages of the new technologies for everyone else and may be described as the 'carrier' and 'motive' branches of the new paradigm.
2. In those sectors, which have been heavily penetrated by microelectronics, both in their product and process technology, there is also evidence of a considerable rise in labour productivity and even some advance in capital productivity in the most recent periods. This applies, for example, to the scientific instruments industry, to the telecommunications industry and to the watch industry. These sectors have now virtually become part of the electronic industry.
3. In sectors where microelectronics has been used on an increasing scale over the past 10 years, but where older technologies still predominate in product and process technology, there is a very uneven picture. Some firms have achieved a very high productivity increases, some have stagnated, while others actually show a decline in productivity. This is the case, for example, in the printing industry, in the machine building industries, and in the clothing industry. This uneven picture is completely consistent with Solter's 1960 vision of the spread of new technologies within established industries through new capital investment. In many cases, information technology is introduced in a piecemeal fashion in one department or for one activity and not as part of an integrated system. For example, one of a few CNC machine tools are introduced or a few robots or word Processors. These are small 'islands' of automation. This is not yet a computer-integrated manufacturing or office system and does not yet achieve anything approaching the full potential productivity gains. There may even be a temporary fall in productivity, because of the lack of the necessary skills in design, in software, in production engineering, in maintenance and in management in general. Problems of institutional and social adaptation are extremely important, and flexibility in social response is very varied between countries, as well as between enterprises. Among OECD countries, Japan and Sweden appear to have been particularly successful in making progress in the area of 'mechatronics'. But the US, which has been rather successful in achieving productivity gains in the microelectronics area (although much less so than Japan), has been rather unsuccessful in the mechatronics area, with the partial exception of defence-based industries.
4. Sectors producing standardised homogeneous commodities on a flow production basis in large plants have made considerable use of information technology in their process control systems and in various management applications. They were indeed among the earliest users of computers for these purposes. This applies, for example, to the petrochemical, oil, steel and cement industries. This has helped them to achieve considerable improvements in their use of energy and materials, but the gains in labour productivity have often been less than in the 1950s and 1960s. Capital productivity in these firms usually shows a marked decline. To understand this phenomenon; it is essential to recognise that these industries are among those most heavily affected by the shift from an energy-intensive and materials-intensive mass production technological paradigm to an

information-intensive paradigm. At the height of the consumer durable and vehicle consumption boom of the 1950s and 1960s, they were achieving strong labour productivity gains based on big plant economies of scale. But with the change in the technological paradigm, the slow-down in the world economy, and the rise in energy prices in the 1970s, they now often face problems of surplus capacity and high unit costs based on below-capacity production levels.

5. Service sectors which are completely based on information technology - software services, data banks, computerised information services, design services, etc. - are among the fastest growing and, for individual firms, the most profitable activities in the leading industrial countries. But also their growth potential is enormous, they so far account for only a small proportion of total services output and employment. Productivity statistics are extremely difficult to generate, but inferential evidence suggests high rates of growth.
6. Some other service sectors have been considerably affected by information technology, such as banking, insurance and distribution, in these sectors, although the diffusion of new technology is extremely uneven, both by firms and country, there is evidence of significant gains in labour productivity. This phenomenon is rather important because hitherto it has often been observed that the service sector of the economy was not capable of achieving the type of labour productivity gains achieved in manufacturing. Information technology now offers the potential (and in some cases already the reality) of achieving such gains outside the manufacturing. However, the progress of technology depends on institutional and structural changes.
7. In most service sectors, information technology still has diffused only to a small extent, and these areas are still characterised by very slow labour productivity gains or none at all. The stagnation in labour productivity in these sectors may be attributed to the lack of information technology, but it certainly cannot be attributed to the impact of information technology. These account for by far the larger part of the tertiary sector.
8. Finally, in many industrialised economies there are sectors, which have shown labour productivity gains over the past 10 years, which are due far more to structural rationalisation than to the direct impact of new technology. Examples are the textile and food industries and also the oil, steel, cement and petrochemical industries, where plant closures and rationalisation have been implemented. Since in any industry there is always a 'tail' of low productivity plants, a significant rise in average labour productivity can always be achieved simply as a result of scrapping the older generations of plants. It is possible even without any further technical improvements in the recent plants, which can now work closer to lull capacity. This may be described as the 'Verdun' effect in contrast to 'Verdoorn' effect of the high boom period.'

Appendix 2: Explicit innovation policies in Latin America (Correa, 1995)

The set of 'explicit' measures adopted to promote innovation, especially for industrial activities, in various Latin American countries have included:

(a) Tax incentives: These incentives were established for a short period (1971-73) in Argentina, with very meagre results. A limited deduction of R&D expenditures has been permitted under Brazilian tax law, as well as in other countries (e.9. Peru, Venezuela). The 'New Industrial Policy' of Brazil has contemplated the establishment of Programs of industrial technological development in the framework of which a set of fiscal incentives may be granted. They include lax exemptions for the import of equipment, reductions in income tax, and other measures (still largely non-implemented). In general terms, and due to a multiplicity of factors, the fiscal instruments seem to have had a quite marginal impact on the effective creation of innovative capabilities in the region.

(b) Financial support: The number, scope and sophistication of the instruments available in the region to finance innovation at the enterprise level increased during the 1980s. In addition to some unsuccessful attempts of the Banco, Brazil has developed different lines to support local innovation, including almost all stages from product development to the setting up of quality control systems, the adaptation and acquisition of foreign technologies etc. It also supports national consultancy firms, currently experiencing a serious crisis resulting from the drastic reduction in international financing and in the investment and maintenance programs of public enterprises. The risk sharing mechanism of CONACYT of Mexico and the activities of the Fondo de Fomento de la InnovacionTecnologica (FINTEC) of Venezuela are other examples worthy of mention, although the budgets they have available for innovative activities have been small.

(c) Linkages between research institutions and enterprises: A range of instruments has also been established in order to strengthen the traditionally weak linkages between research institutions (particularly in universities) and the productive sector. They have included a special contribution (2% of net income) of industrial enterprises in Peru, the creation of innovation' centres in Mexico (sponsored by the Universidad Autonoma de Mexico) and in Colombia (supported by COLCIENCIAS), and the establishment of a vast number of foundations and other entities, including enterprises such as GODETEC in Campinas associated to universities in Brazil. Another interesting development in Brazil is the establishment of 'technology parks' or 'poles', often with significant support of the local states, aimed at creating scientific and industrial complexes. BIORIO, for instance, foresees the installation of about 70 biotechnological firms and a total investment of around US$100 million.

(d) Information services: Finally, and in part taking advantage of the potential of information technologies, some efforts have been made in the region to facilitate the diffusion of scientific and technological information. One example is the database on patents operated by the Instituto Nacional de Propriedade Industrial, which supplied almost 300,000 copies of documents in 1988, mainly through the 'Program of Automatic Supply of Technological Information'.

Appendix 3: Acquisition of foreign technology (Dahlman, Bruce Ross-Larson, and Westphal, 1987).

Dahlman and Westphal say that much discussion about the acquisition of foreign technology focuses on how the technology is transferred rather than on what technological elements are being transferred and why they are being acquired overseas. Their major conclusions are summarised below:

- Direct foreign investment, whether in a wholly owned subsidiary or in a joint venture with minority or majority local participation, is likely to be the only way to obtain the latest information from abroad. Such arrangements can ensure a rapid transfer of technology to a developing country - that is, a rapid transfer of technological information and means, but not necessarily understanding. The lack of local control in such investments can nevertheless have several deleterious outcomes for local technological development.
- Licensing can also enable the rapid acquisition of product or process know-how. It can permit more local control over adaptations and modifications, especially after the license expires. And it can broaden the variety of sources tor technological and other inputs far beyond what is possible under direct foreign investment. The main problems with licensing are in absorbing the foreign technology and in keeping current with advances in that technology.
- Turnkey projects, like direct foreign investment and licensing, can bring technology to a developing country quickly. Because outsiders are responsible for all aspects of construction and start-up, the turnkey project is the quintessential black box, unless special efforts are made to take part in the design of the project and to understand what it makes it work.
- Purchases of capital goods provide another way of acquiring the means of production without the transactional baggage of licenses and direct foreign investment - and a cheap way, if they can be used as models tor reverse engineering to produce the machines locally. But many times the new operating environment for a machine requires changes that the instructions do not cover because they pertain to the original environment.
- Purchases of technical assistance can fill gaps in technological information and understanding to complement the country's capabilities in production, investment, and innovation. The advantage of such purchases is that it may be easier, cheaper, and quicker to rely on foreigners than to take the time and effort to do it locally, possibly making costly mistakes in the process. The disadvantage of technical services is the tendency towards persistent reliance on such services, toward doing little to build up domestic capabilities in providing those services easily, cheaply, and in ways that more fully consider local requirements.

Appendix 4: Dakar Declaration

It has to be remembered that the Dakar Declaration advised two major directions for African countries:

1. To make choice of development strategy suitable to the objective situation of a given country without forgetting the balanced growth in all the major sectors; without separating development from the social process of full employment, income distribution, and the solution of the problems of health, nutrition, housing and education; and with the democratic participation of the masses.
2. To redress the weakness of African scientific and technological capacity by developing schools, colleges and universities and a policy aimed at democratisation and reorganisation of instruction, especially the upgrading of scientific and technical education at all levels. This is because human resources are a country's main wealth.

With regard to resource allocations the Dakar Declaration recommended the following:

1. Financial Resources for R&D: Each country should at least allocate 1% of its GNP to scientific and technological activities by 1980. (Lagos Conference had recommended 0.5% of GNP to R&D).
2. Special Fund for R&A UNESCO should establish a special fund for Africa for strengthening and launching of R&D activities including training at the appropriate level of R&D manpower.
3. Human Resources: For countries with GNP $200 and above, 2000 scientists and engineers per million inhabitants of which 200 (10%) should be engaged in R&D; for countries with GNP between $100- $200, 1400 scientists and engineers per million inhabitants of which 140 must be engaged in R&D; for countries with a GNP below $100, 1000 scientists and engineers, with 100 engaged in R&D. It was also agreed that the member states will continue to provide two technicians for each scientist or engineer engaged in R&D activities as recommended in the Lagos Conference.

Appendix 5: AISI vision of sustainable information society in Africa

AISI came with suggestions on priority strategies, programmes and projects, which can assist in the sustainable, build up of an information society in African countries. This is in accordance with the regional integration goals of the treaty establishing the African Economic Community, which foresaw the necessity of information networks and regional databases, information sources and skills capacities. This has come at a time when there is a growing concern, within the international community, that the continent might become marginalised from the global connectivity and global economy. AISI vision, strategic objectives and what it expects from member countries is given below.

By the year 2010, the AISI is intending to realise a sustainable information society in Africa where:

- Information and decision support systems are used to support decision making in all the major sectors of the economy in line with each country's national development priorities;
- Every man and woman, school child, village, government office and business can access information and knowledge resources through computers and telecommunications. - Access is available to international, regional and national 'information highway'', providing "off-ramps" in the villages and in the information area catering specifically to grass-roots society;
- A vibrant business sector exhibits strong leadership capable of forging the build up of the information society.
- African information resources are available which reflect the needs of government, business, culture, education, tourism, energy, health, transport, and natural resources management;
- Information and knowledge are disseminated and used by business, the public at large and disenfranchised groups, such as women and the poor. In particular it wants to make rational choices in the economy (free market) and for all groups to exercise democratic and human rights (freedom of speech and freedom of cultural and religious expression).

Being this the vision AISI has of Africa's future, it makes it clear that each member-State will need to follow the following strategic objectives:

- Ensure the continuous flow of information within the society by supporting initiatives to improve and create new information and communication services in different sectors of the society - education, health, employment, culture, environment, trade, finance, tourism, transport and commerce;
- Create a continent-wide information and telecommunication network that allows low-cost and reliable communication with other users in Africa and across the globe.
- Achieve maximum benefits from available information by encouraging the development of systems that allow wide dissemination to individuals, business communities, non-government organisation (NGOs) and the public sector;
- Foster a new generation of men and women in Africa that uses information and communication technologies to leverage the development of their nations.
- Link Africa with the rest of the world by improving the flow of new technologies in both directions and exporting intellectual products and services to the rest of the world. What the AISI is trying to do is give a broad guideline framework to serve for each African country as a checklist for things that need to be done to get connected and avoid the risk of being left out in a world increasingly being informatised. It is up to each country, therefore, to take policy measures to reverse the

unfavourable situation in which the continent is found. Many international donor agencies have shown willingness to help fund such projects that can help Africans get connected to the world.

AISI has proposed the following actions as an integral part of national plans and programmes that each member-State should consider:

1. Develop a master plan for building national information and telecommunication infrastructures and a two-to-five-year plan for the implementation of the basic infrastructure.
2. Establish a strong regulatory body, independent from telecommunications operators and their ministries, to stimulate and regulate public/private sector partnerships, with a view to safeguarding the goal of "universal service" and to review fiscal policies (such as tariffs, duties and license fees).
3. Eliminate or drastically reduce import tariffs, taxes and other legal barriers to the use of information and communication technologies.
4. Establish an enabling environment to foster the development of information and communications in society, including measures which energise the private sector to play a leading market role in the provision of services and in the human resources development needed to use them effectively;
5. Implement a policy for using information and communication technology in government services and develop national databases in all key sectors of the economy and national administration;
6. Conduct needs analysis to determine requirements and set up information and communication services in key sectors of national priority, especially education, health, employment, culture, environment, trade, finance, tourism and transport;
7. identify and develop information technology applications in areas with highest impact on socio-economic development at the national level.
8. Take immediate steps to facilitate the establishment of locally based, low-cost and widely accessible Internet services and indigenous African information content.
9. Prepare and adopt plans to develop human resources in information and communication technologies.
10. Adopt policies and strategies to increase access to information and communications facilities, with priorities in serving the rural areas, grass-root society and other disenfranchised groups, in particular, women and youth;
11. Make special efforts to create awareness among those unfamiliar with the potential benefits of the African information infrastructure with particular attention to gender equity.
12. Together, member States will need to develop a co-ordinating mechanism to ensure successful implementation of the AISI to maximise complementarities; share lessons learned and reduce duplication of activities.

Appendix 6: Major international agencies and organisations involved in Internet initiatives in Africa

- Association for Progressive Communication (APC),
- Bellanet.
- Canadian International Development agency (CIDA),
- Consultative Group for International Agricultural Research (CGIAR),
- ECA's Africa's Information Society Initiative (AISI),
- Information Centre for Low-External-Input and Sustainable Agriculture (ILEIA),
- InfoDev,
- International Development Research Centre (IDRC),
- International Telecommunications Union (ITU),
- International Fund for Agricultural Development (IFAD),
- Inter Press Service Third World News Agency (IPS),
- NASA,
- Organisation of American States (OAS),
- Technical Centre for Agricultural and Rural Cupertino (CTA),
- United Nations Development Programme (UNDP),
- United Nations Economic Commission for Africa (UNECA),
- UNESCO,
- UN Secretary General's Special Initiative on Africa,
- USAID,
- World Bank, World Bank's Electronic Media Centre (EMC),
- International Institute for Communications and Development, and others.

Appendix 7: detailed list of other computer brands in the country

1. Daewoo
2. Vectra
3. IBM compatible (cloned)
4. NCR
5. Amstrad
6. AST
7. Rosari
8. Philips
9. Leo
10. Bright
11. Axion
12. Smile
13. VIP
14. North Rop Gruman
15. Apple Mac
16. Apollo
17. Success
18. Acer
19. CTX
20. CINET
21. Clone Act
22. Atena
23. IDP
24. Thor
25. Olidata
26. Tandon
27. Voltra
28. Explorer
29. JD 144 D
30. Gold Star
31. Intelscan
32. Gateway
33. Intelect
34. NEC
35. PC Net
36. GLT
37. FGG
38. SET
39. SFA
40. PC Tech
41. Fujitsu
42. ADT Provista
43. AGC/KTX/Topscan
44. Nicom
45. Dal
46. Melstar
47. Ashford
48. Konica
49. AST
50. Quadra
51. Safari
52. MBC
53. Arche Rival
54. AC Com PC
55. AUVA
56. HP
57. Magistronic
58. Phonex
59. High Screen
60. Mel
61. Cliker
62. Pearl
63. MCM

Appendix 8: Other software used in the country

1. Ms-Outlook & Scheduler
2. Harvard Graphics
3. MAS 90 Accounting software
4. EPINF
5. Page Maker
6. Central & Jacard for Sweater Designing
7. GIS (Geographic information Systems)
8. Accounting Packages such as Quick Books and Money
9. Pascal
10. C language
11. DBase
12. Power Point(Ms)
13. Geez Gate
14. Path Finder: Surveying Software
15. Quattro-Pro
16. Geosciences Software
17. Geochemical Software
18. Map Production Software
19. UNIX
20. SPSS
21. Adobe Illustrator. R 6
22. Adobe Photoshop, TM 2.5
23. Adobe Streamline, TM 3
24. Quick Express, R 3.3.1.
25. Ex-Accounting
26. EPt-50
27. Aldus Page Maker
28. Yada
29. ProMS (Program manager system)
30. Priceman
31. CONCORD (accounting software)
32. DIAL UP Networking
33. MS Messaging
34. MS Power Point 97
35. WordPerfect 5.1, and 6.
36. 36.Excel 5.0
37. Claris file maker Pro.(data base)
38. MS Works
39. IBPS, ReDATUM Plus, ISSA, Port Pac (statistical software)
40. Operating System 5400
41. BPG2 (COBOL, FORTFTAN for minis)
42. Winsome (accounting)
43. AmiPro
44. MC Afee
45. Lotus Smart Suite
46. Print Shop
47. TINET (Trade Information Network of COMESA stale members)
48. CLIPPER
49. Paradox
50. CAD
51. Floor Plan Plus 3D
52. Winfax LIR
53. I Photo Plus
54. Perceive
55. MS Project
56. First Aid
57. PC Copier
58. Mustek
59. Novel 3.1 2
60. Oracle
61. Designer 2000
62. OPAC (Libris)
63. CC-Mail
64. Developers Kit
65. Compilers
66. Quick Link
67. COREL DRAW
68. LEAP

Appendix 9: List of organisations surveyed

1. Eritrean Information Services Agency (EISA)
2. Central Personnel Administration (CPA)
3. National Statistics
4. Head Office of the Ministry of Local Government
5. Eritrean Police Commissioner Office
6. Prisons Administration
7. Head Office Ministry of Foreign Affairs
8. Emigration Office
9. Budget Office
10. Department of Inland Revenue
11. Department of Treasury
12. Procurement and Government Property Control
13. Customs and Finance Guard
14. Bank of Eritrea
15. Commercial Bank of Eritrea
16. Government Garage
17. Office of Auditor General
18. License Office
19. Investment Centre
20. Grain Board
21. Eritrean Standards
22. Department of Trade
23. Department of industry
24. Research and Training, MTI
25. Department of Labour
26. Department of Social Welfare
27. Administration and Finance. MLHW
28. Department of Research and Development, MLHW
29. ERBEC
30. Department of Land Transport
31. Department of Communications
32. Department of Maritime Transport
33. Post Office. Head Office
34. Department of radio and TV
35. Department of Press and News Agency
36. Department of Engineering, MoI
37. Department of Mines
38. Department of Energy
39. Department of Environment
40. Housing commission
41. Land Commission
42. National Food Information Systems, MoA
43. Ministry of Justice, Head off ice
44. Department of Road construction
45. Ministry of Education, Head Office
46. University of Asmara
47. Ministry of Health, Head Office
48. Ministry of Tourism, Head Office
49. Department of Research, MoF
50. National Agency for Supervision and Privatisation of Public Enterprises
51. National Confederation of Eritrean Workers(NCEW)
52. National Union of Eritrean Youth and Students (NUEYS)
53. National Union of Eritrean Women (NUEW)
54. Teachers Association
55. National Association of the Blind
56. Dahlak Shoe Factory
57. Sembel Household Utensils Factory
58. Asmara soap Factory
59. Halay Sweet Factory
60. Asmara Meat & Milk Factory
61. Lalemba sack Factory
62. Africa Matches & Paper Factory
63. Deluxe Shoe Factory
64. National Edible Oil Factory
65. Asmara Ceramics
66. Eritrea Cackles Factory
67. Eritrea Textile Factory
68. Asmara Textile Factory
69. Asmara Pickling Factory
70. Red Sea Tannery
71. Orota Metal Works
72. Asmara Brewery
73. Selam Hotel
74. Ambasoyra Hotel
75. NICE
76. ERI-SOC
77. Orota No.1 Metal Work
78. Transhorn Transport Co.
79. Garage Fenkel
80. Seghen construction
81. Red Sea Trading Co.
82. Housing and Saving Bank
83. Foreign Exchange Bureau
84. Eritrea Shipping Lines
85. Eritrean Tour Service
86. As.Be.Co.
87. Ghirmay Berhane Semereab(GEM Information Management)
88. Maaza Hailemichael Misghina(TFanus)
89. Ermias Solomon Yosief

90. Mustafa Abdel-Aziz Seid-Abadr (JMC Computer Centre)
91. The Elma Computer Centre
92. Amanuel Tesfai
93. Tekle Abraha Bahta (Professional Computer Services)
94. Abacus Computer Services
95. Bruke Habtemichael Solomun (SBM)
96. Abdelrahman Saleh Shagaray
97. Infotec Engineering P.l.c.
98. institute of Computer Services
99. Berhane Asfeha Dagnew (Africa Computer Technology)
100. Kibrom Berhane Gebreselassie &Sons P.l.c.
101. Mohammed Ali Jaffer (Asmara Computer Centre)
102. Mnasie Tekie Mehreteab
103. Tesfayohanes Kesete Teklemichael
104. Eyob Habtemariam Tesfa
105. Teslay Girmay Gilagiorgis
106. Eden Computer Services
107. Misgina Sium Gebregiorgis
108. Robel Weldemichael Abraha (Ericom 2000)
109. Alem Tekeste Zemuy
110. Sewit International P.l.c.
111. Computer Technology Services
112. Yohannes Negash Bokre (Tesat IBM)
113. Habte Tsegai
114. Natural Resources Consultant Engin.
115. Seifemichael Berhe
116. Drilling and Geotechnical Services
117. Estifanos Okbazghi
118. Girmay Sengal
119. Josef Tzegai Tekie
120. Ghebremedhin Haile
121. Abu-Husein
122. Studio Michael Tedros Arch.& Urb.
123. Kaltec Consulting Arch.& Eng.
124. Gebremeskel Teare Constr. Arc. Eng. & P.l.c
125. Tsegai Elias
126. FASTEC Electrical Engineering Consultancy
127. Photo Zula
128. Selam Photo Studio
129. Photo Bini
130. Sahil Photo studio
131. Photo Cathedral
132. Photo Soark
133. Photo red Sea
134. Photo Eritrea
135. Photo city
136. Sunshine Hotel
137. Legesse Hotel
138. Ambasador Hotel
139. Gash Garment Factory
140. Harambe Sweater Factory
141. Tsehaye Mogos Sweater factory
142. Red Sea Bottlers
143. Gash Cigarette Factory (Rothmans)
144. Red Sea Soap Factory
145. Chipollini Shoe Factory
146. LIALF Sh.Co.
147. Prima Eritrea Oil Company
148. Anadarco
149. Space 2001
150. Keangnam Enterprises
151. CMC
152. East African Construction
153. Eritrean Korean Furniture Manufacturing Co.
154. Eritrean Painting Factory
155. Aluminium Extrusion Plant
156. Nakfa Corporation
157. Mereb corporation
158. MBY(Printing Press)
159. Universal Trading Graphics
160. Sabur Printing Press
161. Selam Ultra-sound Clinic
162. Dr. Efrem Zeweldi Clinic
163. Polyclinic (near Betemengisti)
164. Asisa Travel agency P.l.c.
165. Hassen Mohammed-Ali Hassen
166. Heron Travel Agency
167. Solomon International Trading
168. Kekia Transport & Investment Co.
169. UNICEF
170. WHO
171. FAO
172. USIS
173. UNDP
174. British Council Library
175. Public Library

Appendix 10: List of persons interviewed

1. Teklemariam Ghebreselassie, Fainance and Administration Manager of NICE, October 8, 1997.
2. Dr. Ghirmay Abrham, Economic Advisor to BE, and KiflomTekleab , Systems Manager of BE, October 10, 1997.
3. Tewelde Ghebreab, Director of EritreanInformations Systems Agency, October13, 1997.
4. Yemane Ghebremariam, IT Manager of Commercial Bank of Eritrea, October 14, 1997.
5. Andemariam Ghebregiorgis, Head of Data Processing of TSE, October 16, 1997.
6. Berhane Demoz, Research Section of RHRD of ministry of Education, October 19, 1997.
7. Tsigereda Tekle, Head MIS of Ministry of Local Government Head office, October 22, 1997.
8. Solomon Habtom, Maintenance Branch Head TSE, October 22, 1997.
9. Tadesse Weldeyohannes, Head of Research & Development of the Ministry of Trade & Industry, October 23, 1997.
10. Biniam Tesfay, Progaram Analyst of Ministry of Trade & Industry, October 23, 1997.
11. Abraham Tekle, Head of Human Resource Development of the Ministry of Education, October 27, 1997.
12. Samuel Baire, Director General of the Ministry of Energy, October 27, 1997.
13. Abraham Weldemichael, Eritrean Electric Authority Manager, October 27, 1997.
14. Petros Tesfagiorgios, Planning & Human Resource Development Head of the CBE, October 28, 1997.
15. Haddish Tesfagiorgis and Tesfaldet Gebreab, Programmers of Data Processing Office of EEA, October 29, 1997.
16. Zerai Abraham, Deputy Director of EISA, October 29, 1997.
17. Vittorio Giovanni, Planning Head of TSE, November 1, 1997.
18. Tesfaselassie Berhane, Director of License Office, November 10, 1997.
19. Weldeghebriel Beraki, Owner Manager of Alem Computer Centre, November 11, 1997.
20. Dr. Berhane Haile, Head of Health Information Systems Unit of the Ministry of Health, November 26, 1997.
21. Berhane Abrehe, Director of Macro Policy Office, December 3, 1997.
22. Mr Norman Piccioni, FAO Consultant of the Ministry of Agriculture, December 8, 1997.
23. Ghirmay Kidane, Head Air Traffic Services of the Civil aviation, December 9, 1997.
24. Menghisteab Habtegiorgis, Technical Head of Meteorology, December 9, 1997.
25. Ainom Berhane, Director of National Statistics office, December 10, 1997.
26. Alemseged Mesfin, BIT Computer School Owner-Manager, December 10, 1997.
27. Teweldeberhan Mehari, Manager-owner of IBM Tesat, December 12, 1997.
28. Mengis Samuel, Managing Director, and Yohannes Ghebrehiwet, operation Manager of EWAN Technology Solutions, December 17, 1997.
29. Tewelde Estifanos, Technical Director of TFanus, December 18, 1997.
30. Alazar H/Michael, Director CTS, December 23, 1997.
31. Habte Gherenet, K.M. Computers Manager, December 23, 1997.
32. Robel Weldemichael, Ericom 2000Manager, December 23, 1997.
33. Dawit Tekie, Shewit International Deputy Manager, December 30, 1997.
34. Dr. Abraha Ghebremeskel, Manager of ETSS, January 5, 1998..
35. Ahmed Negash, Academic Director of Asmara Computer Centre, January 5, 1998.
36. Mussie Dawit, Technical Director ECET, January 10, 1998..
37. Isaias Fessehaie, General Manager Fred Hollows IOL Manufacturing Plant, February 24, 1998.
38. Kidane Abraha, Production Manager of Fred Hollows IOL Manufacturing Plant, February 24, 1998.
39. Teweldeberhan Dessu, Outside Plant Section Head of TSE, March 23, 1998.
40. Tesfay Moges, International Exchange Head of TSE, March 23, 1998.

Bibliography

Abbott, G.C. (1993). Debt Relief and sustainable development in Sub-Saharan Africa. Edward Elgar, Cambridge, UK.

Adams, C. & Cavendish, W. (1991). 'Can privatisation succeed: economic structure and programme design in eight Commonwealth countries', Centro Studi Luca D'Agliano and Queen Elisabeth House Discussion Papers, 34.

Adedeji, A., (ed.), (1981). Indigenisation of African economies. Hutchinson & Co. Ltd., London etc.

Adler, E. (198'l) The Power of ideology: The Quest for Technological Autonomy in Argentina and Brazil, University of California Press, Berkeley, p. 185.

Africa File and ISPA Nord/Sud (199i). The African computer market: a market survey. Hitchin, Herts, UK: IT?
African File, Angus House.

African Academy of Sciences/American Association for the Advancement of Science (1992). Electronic networking in Africa: advancing science and technology for development. Workshop on science and technology communication networks in Africa. August27-Z9, Nairobi, Kenya.

African Council of Communication Education (Ghana Chapter). New communications technologies (1987).

Ahmmed, Aqueil, ed. (1993). Science and technology policy for economic development in Africa. E.J.Brill: Leiden, New York, Koln, 1993.

AISI, Http.//www,idsc.gov.eglaiilintro,htrn

Ajeyalemi, D. ed. (1990). Science and Technology Education in, Africa: focus on seven Sub-Saharan countries, Lagos: University of Lagos Press, p. 194.

Akinalde, T. O. (1989). 'Information Technology in Nigeria: problems and prospects', Information Technology for Development,4(3).

Alabi, G. A. (1996). AISI case study: empowering socio-economic development in Africa utilising information technology, a critical examination of the social, economic, technical and policy issues in Nigeda. http://www. bellanet. org/partners/aisi/policy/entry/nigeria.htm

Allen, T.J & Scott-Morton, M.S, eds. (1994), Information Technology and the Corporation of the 1990s, Research Studies, Oxford: Oxford University Press.

Allen, T.J. (1977). Managing the flow of technology. MIT Press,

Amirahmadi, H., & Wallace, C. (1995). Information technology, the organisation of production, and regional development. Environment and Planning,2T(1 1), November, pp. 1745-75.

Amsden, A. (1989). Asia's Next Giant: South Korea and Late Industrialisation, New York: Oxford University Press.

Anderson, E., Dalum, B. & Villumsen, G. (1981) The importance of the home market for the technological development and the international specialisation of manufacturing industry. Technical Innovation and National Economic Performance, IKE Seminar, Aalborg: Aalborg University Press.

Antonelli, C. (1986). The international diffusion of new information technologies. Research Policy, 3, pp.139-147.

Antonelli, C, (1990). Induced adoption and externalities in the regional diffusion of information technology. Regional Studies,24(l), February, pp. 3l-40.

Antonelli, C. (1990). Information technology and the derived demand for telecommunication services in the manufacturing industry. Information economics and. Policy, 4(1), i989-90, pp. 45-55.

Antonelli, C. (1991). The diffusion of advanced telecommunications in developing countries Development Centre Studies, Paris, Organisation for Economic Co-operation and Development Centre.

Antonelli, C. ed. (1988). New information technology and industrial change: the Italian case. Kluwer Academic, Dordrecht and Boston.

APO (Asian Productivity Organisation) (1990). Information technology-led development. Tokyo: APO,

Araia Tseggai (1981). The economic viability of an independent Eritrea. PhD. Dissertation, University of Nebraska.

Archambault, E. I. (1992). Incremental or radical change in semiconductors manufacturing? Some evidence from South Korea, mimeo, Science Policy Research Unit, University of Sussex, England.

Assoku, R. K G (1996). The Ghana experience with regard to research training and brain drain. Proceedings of a conference on research training for countries with limited research capacity. Roskilde University Press.

Attewell, P. (1991). Information technology and the productivity paradox. Working Paper, New York: Department of Sociology, City University of New York.

Axelsson, G. & Docherty, P. (1990). IT and Organisational Change: Experiences from the Swedish Public Service. Proceedings of the Meeting of Senior Officials for the Management of Information Technology in Public Administration. OECD, Paris.

Ayiku, N. B. (1989). A case study in process automation in Ghana. Information Technology for Development, Vol.4, No.2.

Bagachwa, M. S. D. & Stewart, F. (1992). Rural industries and rural linkages in Sub-Saharan Africa. In S. Lall, F Stewart & S. M. Wangwe (Eds.), Alternative development strategies for African development. London: McMillan.

Bagchi, A K,, ed (1995). New technology and the workers' response: microelectronics, labour and society. With the assistance of Ranabir Samaddar, New Delhi, Thousand Oaks, California and London: SAGE Publications.

Baily, M. N. & Chakabarti, A.K. (1989). Innovation and the Productivity Crisis, The Brookings Institution, Washington, D.C.

Baily, M. N. & Gordon, R. J. (1988). The productivity slowdown, measurement issues, and the explosion of computer power. Brookings papers on economic activity, 0(2), pp.347-420.

Baily, M. N (1986). Productivity growth and material use in US manufacturing (productivity and the services of capital and labour). Quarterly Journal of Economics, 101 (1), February, pp. 185-95.

Baily, M. N. (1988). Innovation and the productivity crisis. Washington, D.C.: Brookings Institution.

Baily, Martin N. (1986) What has happened to productivity growth? Science, 234 (4775), pp.443-451.

Balmer, B. (1996). Managing Mapping in the Genome Project. Social Studies of Science,26 (3), pp.531-573.

Baranek, W. & Ranis, G. (1978) Science and technology and economic development. New York: Praeger

Baranek, W. & Ranis, G. (1978), Science and Technology and Economic Development, New York. Praeger.

Baranson, J. (1981). North-South technology, Transfer: Financing and Institution Building Maryland: Lomond Publications.

Barker, C. E., van Mitschke-Collande P. V. & Wield D.V. (1986). African industrialisation: Technology and Change in Tanzania, Gower Publishing Company Limiter, Brooksfield, USA.

Barras, R. & Swann, J. (1984). Information technology and the service sector: quality of services and quantity of jobs. In P. Marstrand, ed., New technology and the future of work and skills. Proceedings of a symposium organised by Section X at the annual meeting of the British Association for the advancement of science, August 1983. London and Dover, N.H.: Pinter, pp. 214-33.

Barrett, S. M. (1990). Information technology and organisational culture: implementing change school for advanced. urban studies. University of Bristol, UK.

Bastos, M. I. (1992). State policies and private interests: The struggle over information technology in Brazil. In H. Schmitz and J. Cassiolato eds. Hi-tech for industrial development: Lessons front the Brazilian experience in electronics and automation. London and New York: Routledge, pp.239-72.
Beer, M. (1990). Why change programs don't produce change. Harvard Business Review, Nov.-Dec. 1990, pp. 158- 166.
Bell, M. (1982). Technical change in infant industries: a review of empirical evidence. Brighton: Science Policy Research Unit, University of Sussex (mimeo).
Bell, M., Ross-Larson, B. & Westphal, L.E. (1984). Assessing the performance of infant industries. Journal of Development Economics, 16 (1/2) Sept.-Oct., pp. 101-28.
Bell, R M. (1984). Training and the accumulation of industrial technological capacity in developing countries. In M. Fransman and King K.
Benjamin, R J. & Blunt, L (1992). Critical IT issues: the next ten years. Sloan Management Review, 33(4), Summer, pp.7-19.
Bensaou, M. & Venkatraman, N. (1993). Inter-organisational relationships and information technology: a conceptual synthesis and a research framework. INSEAD Working Papers: 93I86/TIWSM, p.16.
Berndt, E.R. & Malone, T.W. (1995). Information technology and the productivity paradox. getting the question right. Economics of Innovation and New Technology, 3 (3-4), pp. 177-82.
Bhagavan, MR. (1990). Technological Advance in the World: Strategies and Prospects, Zed Books Ltd.: London and New Jersey.
Bhagwati, J. & Desai, P. (1970). India: planning for industrialisation. Delhi Oxford University Press, Bombay
Bhagwati, J.(1993). India in transition: freeing the economy. Claredon Press, Oxford.
Bhalla, S. K. (1987). The Effective Management of Technology: a challenge for corporations', Battelle Press, Columbus-Richland.
Bhatnagar', S.C. & Odedra, M. eds. (1992). Social implications of computers in developing countries. New Delhi, New York: Tata McGraw-Hill Pub. Co.
Bhatnagar, S.C, ed. (1992). Information technology manpower: Key issues for developing countries. New Delhi, New York: Tata McGraw-Hill Pub. Co.
Bielchowsky, R. (1985). Stuacao do apoio do Governo Federal a' pesquisa fundamental no Brasil. Mimeo, Rio de Janeiro, FINEP.
Biervert, B. & Monse, K. (1992). Creating applications of information technology in the service sector. In Dierkes, M., Hoffmann, U., eds. New Technology at the Outset: Social Forces in the Shaping of Technological Innovations. Boulder: Westview Press, Frankfurt am Main: Campus, pp. 256-76.
Biggs, T. S. & Levy, B. D. (1991). Strategic intervention and the political economy of industrial policy in developing countries. In D. H. Perkins & M. Roemer eds. Reforming economic system in developing countries. Harvard studies in international development, Cambridge: Harvard Institute for Interactional Development, distributed by Harvard University Press, pp. 365-401.
Bigsten, A. (1993). Regulation versus price reforms in crisis management: the case of Kenya. In M. Blomstr6m & M. Lundahl, eds. Crisis in Africa: Perspectives on policy responses, Routledge: London and New York.
Bird, A. & Lehrman, W. G. (1993). The effects of major information technology adoption in Japanese corporations. Japan and the World Economy, 5(3), pp.2l7 -42.
Bird, A. & Lehrman, W.G. (1993). The effects of major information technology adoption in Japanese corporations. Japan and the World Economy, 5(3), pp.217-42.
Blakeney, M. (1989). Legal aspects of the transfer of technology to developing countries. Oxford: ESC Pub.
Blornstróm, M. & Lundahl, M. eds. (1993). Economic crisis in Africa: perspectives on policy responses. Routledge, London and New York.

Board, C (1991). The challenge of information technology. In R. Bennett & R. Estall eds. Global Change and Challenge: Geography for the 1990s, London and N.Y.: Routledge, pp. 242-59.

Boddy, D. & Buchanan, D.A. (1986). Managing New Technology. Basil Blackwell, New York.

Bowden, D. & Blakeman, K. (1989). IT Strategies for Information Management. Borough Green Sevenocks, Kent, UK.

Boynton, A.C. & Zmud, R.W. (1987), Information technology planning in the 1990's: directions for practice and research. MIS Quarterly, March, pp. 59-71.

Brada, Carlos-A. P. (1996). The impacts of the internationalisation of services on developing countries. France and. Development, 33(l), March , pp. 34-37 .

Braun, D. (1993). Who governs intermediate agencies? Principal agent relations in research policy. Journal of Public Policy, 13 (2),pp.135-162.

Brenner, C. & Kurdoglu, C. (1988). Mastering Technology: Engineering Service Firms in Developing Countries. Development Centre Papers: OECD.

Brynjolfsson, E. (1993). The productivity paradox of information technology. Communications of the ACM, 36 (12), pp. 66-77.

Brynjolfsson, E. Hitt, L. (1993). Is information systems spending productive? New evidence and new results. Proceedings of the l4th International Conference on Information Systems (Porlando, FL: December, 1993), pp. 47-64.

Brynjolfsson, Erik & Hitt, L. (1994). Computers and economic growth: firm level evidence. MIT Sloan School of Management, Working Paper No. 3714.

Brynjolfsson, Erik (1994). Some estimates of the contribution of information technology to consumer welfare. MIT Sloan School of Management, Working Paper No. 3647, September.

Bunjun, R. (1986). Status of computer applications in Mauritius. In Commonwealth Science Council, Status of Computer Application (Africa), Technical Series, No. 208, CSC (86) ISP-20, London, October.

Burkhardt, M,E. & Brass, D.J. (1990). Changing patterns or patterns of change: the effects of a change in technology on social network structure and power. *Administrative Science Quarterly*, 35, pp. 104-127.

Burton, J (1999). 'Innovation, entrepreneurship and the firm: a post-schumpeterian approach. Int. J. Technology management, 17 (112), pp. 16-36.

Bush, V. (1947). Endless Horizons. Washington, DC.

Cane, A. (1992), Information technology and competitive advantage: lessons from the developed countries. World Development, 20(12), December, pp. 17 21-36.

Carlsson, B. & Taymaz, E. (1991). The role of technological progress and economic competence in economic growth: a micro-to-macro analysis. Paper presented to the EARIE Conference, Ferrara, Italy, Sept. 1-3, 1991.

Carlsson, J , Forss, K. & Malai, S. (1989). From Competition to Co-operation? An evaluation of MEIDA and its impact on the engineering industries in Tanzania. SIDA evaluation report 1989/4, Institutional Development, Stockholm.

Carnoy, M. (1994). The new global economy, information technology and restructuring education. *Inter.J. Technology Management*, 9(314), pp. 27 0-286.

Carvalho, Ruy de Quadros (1992). Why the market reserve is not enough: Lessons from the diffusion of industrial automation technology in Brazilian process industries. In H. Schrnitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons from the Brazilian electronics and automation. Routledge, London and New York.

Cassiolato, I. (1992). The user-producer connection in hi-tech: A case study of banking automation in Brazil. In H. Schmitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons from the Brazilian electronics and automation. Routledge, London and New York.

Cassiolato, J. E., Hewitt, T. & Schmitz, H. (1992). Learning in industry and government: Achievements, failures and lessons. In H, Schmitz & J Cassiolato eds., *Hi-tech for industrial! development: Lessons from the Brazilian experience in electronics and automation*. London and New York: Routledge, pp.273-316

Castells, M. (1993). The information economy and the new international division of labour. In M. Carnoy et al. eds. Reflections on the new world economy in the information age. Pennsylvania State University press.

Castells, M. (1996) The information age: economy, society and culture (Volume I). The rise of the network society, Blackwell Publishers, Oxford, UK.

Castells, M. (1998). The information age: economy, society and culture (Volume III). End of millennium. Blackwell Publishers, Oxford, UK.

CCET, (1996). Review of national science and technology policy. Poland, OECD.

Cerbella, G. (Dott.), (1959). Eritrea 1959: la colletivitá Italiana nelle sue attivitá economiche sociali e cultulali. Consolato Generale D'Italia. Asmara.

Ceylon, T, (1936). L'Africa Orientale Italiana: la rassegna Italiana. Roma, 1936, pp.157-60.

Chan Kong, C.Y.J. (1986). Informatics Technology Status in Mauritius. Proceedings of the Southern African workshop on informatics for development. Victoria Falls, Zimbabwe, May.

Chang, Pao-Long; Shih, -Chintay & Chiung-Wen Hsu (1993). Taiwan's approach to technological change : The case of integrated circuit design. Technology Analysis & Strategic Management, 5 (2), pp. 173-177.

Chatterji M. ed. (1990). Technology Transfer in the Developing Countries. The Macmillan Press: London.

Chen, E.K.Y. (1979). Hyper-Growth in Asian Economies: A Comparative Study of Hong Kong, Japan, Korea, Singapore and Taiwan- London, Macmillan.

Chilambe, P. E. (1986). Information technology in Malawi. Proceedings of the Southern African workshop on informatics for development. Victoria Falls, Zimbabwe, May.

Chilambe, P. E. (1987). Information technology in government of Malawi, Paper presented at the Eastern and Southern African workshop on information technology in government. Rusape, Zimbabwe, April.

Child, J. (1987). Information technology and organisation. In K. Urabe, J. Child & T. Kagono eds. Innovation and Management Walter de Gruyter, New York.

Chilwesa, M.S (1995). 'The technology market forum for the Common Market of Eastern and Southern Africa. Techmart COMESA '95, held from the 17-20 Oct. PYA Exhibition Village, Showgrounds- Lusaka.

Cho, Dong-Sung; Kim, Dong-Jae & Dong Kee Rhee (1998). Latecomer strategies: Evidence from the semiconductor industry in Japan and Korea. Organisation Science, 1.9 (4), July-August, pp. 489-505.

Choi, Hyung-Sup (1986). Science and technology policy for industrialisation of developing countries. Technological Forecasting and Social Change, 29, pp.225-239.

Choi, Hyung-Sup (1988). Direction for technological self-reliance - Korean approaches. Technological Forecasting and Social Change, 33, pp.23-32.

Choi, Hyung-Sup (1988). Science policy mechanism and technology development strategy in developing countries. Technological Forecasting and Social Change, 33, pp. 279-292.

Chudnovsky, D., Nagao, M., & Jacobsson, S. (1984). Capital goods production in the third world: An economic stud1, of technical acquisition. London: Frances Pinter.

Clark, N. & Parthasarathi, A. (1982). Science-based industrialisation in a developing country: The case of the Indian scientific instrument industry 1947-1968. Modern Asian Studies, 16.

Cline, W. R. (1987). Mobilising bank lending to debtor countries: Policy analysis in international economic series, No. 18 Washington, D. C.: Institute for International Economics.

Cockcroft, L. (1992). The past record and future potential of foreign investment. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.

Cody, J , Hughes, H. & Wall, D. eds. (1980). Policies for industrial progress in developing countries. London: Oxford University Press in Associat.ion w.ith UNIDO and World Bank.
Cohen, R.B. (1995). The economic impact of information technology. Business Economics, 30 (4), October, pp. 21-25.
Communications Department. First Quarter Report, 1998
Coombs, R., Saviotti, P. & Walsh, V. (1987). Economics and technological change, Macmillan Education Ltd., London.
Cooper, C. (1974). Science policy and technological change in underdeveloped economies. World Development, 2(3).
Cooper, C (1980). Policy interventions for technological innovation in developing countries. Washington, DC: World Bank, Staff Working Paper No.441.
Cooper, C. (1994). Science and technology in Africa under conditions of economic crisis and structural adjustment UNU/INTECH working paper no. 4, Maastricht: United Nations University, Institute for New Technologies.
Couca, C. M. (1996). Strategies for software exports from developing countries. World Development, 24 (1),pp. 171-182.
Correa, C.M. (1995). Innovation and technology transfer in Latin America: A review of recent trends and policies I nt. J. Technology Management, 1 0(7 I 8), pp. 8 I 5-846.
Coulson A. (1982). The state and industrialisation in Tanzania. In M. Fransman. ed., 1982.
Court, D. (1991). The intellectual context of educational research: Reflections from a donor in Africa. Paper for meeting on strengthening analytical research capacities in education. Bonn, July,
Crane, D. (1977). Technological innovation in developing countries: Are view of literature. Research Policy, 6 pp. 374-95.
Cumbane, S. (1986). Status of informatics in Mozambique. Proceedings of the Southern African workshop on informatics for development. Victoria Falls, Zimbabwe, May.
D. Gemeda (1996). Experiences of Addis Ababa University in national graduate training and research.
Proceedings of a conference on research training for countries with limited research capacity. Roskilde University Press.
Dahlman, C. J. & Frishtak, C. R. (1993). National systems supporting technical advance in industry: The Brazilian experience. In R. R, Nelson ed. National innovation systems: A comparative analysis. New York Oxford, Oxford University Press.
Dahlman, C. J. & Sercovich, F. (1984). Exports of technology from semi-industrialised economies and local technological development. Journal of Development Economics, 16 (1/2), Sept.-Oct., pp. 63-99.
Dahlman, C. J. & Westphal, L. (1982). Technological effort in industrial development: A survey. In Stewart and James (1982).
Dahlman, C. J. & Westphal, L. (1983). The transfer of technology - issue in the acquisition of technological capability by developing countries. Finance and Development, 20 (4).
Dahlman, C. J. (1982). Foreign technology and indigenous technological capability in Brazil. Paper presented at the University of Edinburgh workshop on facilitating indigenous technological capability. Edinburgh.
Dahlman, C. J. (1984). Foreign technology and indigenous technological capability in Brazil. In Fransman and King (1984).
Dahlman, C. J., Ross-Larsen B., & Wesphal, L. (1987). Managing technological development: Lessons from the Newly Industrialising Countries. World Development, 15(6), pp. 759-775.
Dahlman, C.J. & Fonseca, F.V. (1978). From technological dependence to technological development: The case of the Usiminas Steel Plant in Brazil. Buenos Aires: IDB/ECLA,TUNDP/DRC Regional Program of Studies on Scientific and Technical Development in Latin America, Working paper 21.

Das, D.K. (1992). Korean economic dynamism. MacMillan Academic and Professional Ltd., London.
Datapro (1991), Indonesia: The commercial and regulatory environment. Datapro reports on international telecommunications. Delran, NJ: McGraw-Hill.
Datta Mitra, J. (1979). The capital goods sector in LDC's: A case for state intervention? Washington, DC: World Bank, Staff Working Paper No. 343.
Datta, A. & Baffour-Awuah, M. (1988). Botswana: Development and co-ordination of Information and informatics policies. Paper presented in National Information and Informatics Policies in Africa: Report and Proceedings of a Regional Seminar, Addis Ababa, Ethiopia, 28 Nov.- 1 December.
Datta, Baffour-Awuah (1988). Paper presented in the national information and informatics policies in Africa: Report and Proceedings of a Regional seminar. Addis Ababa, Ethiopia, 2g Nov- 1 Dec, I 9gg,
Davenport, T. (1993). Process innovation: Re-engineering work through information technology. Harvard Business School Press, Boston.
Davenport, T., R. Eccles, Prusak, L. (1990). Information technology and business process redesign. Sloan Management Review, Summer, 31 (4), pp. 11-27.
David, P.A. & Creenstein, S. (1989). Compatibility standards and information technology--business strategies, market development, and public policies. Stanford Centre for Economic Policy Research Discussion Paper Series: 159, May 1989, p. 20.
David, P.A. (1975). Technical change, innovation and economic growth. London' Cambridge University press
David,C, Tiffin, S & Osotimehin, F. (1994). Developing capacity in management of science, technology and innovation in Africa. Int. J. Technology Mandgement,9 (1), pp. 43-60.
Davis, C. H. (1983). L'UNESCO et la promotion des politiques scientifiques nationales en Afrique Subsaharienne. Etudes Internationales, 14(4),pp. 621-638.
Deans, P.C., et. al., (1991). Identification of key international information systems issues in U.S based multinational corporations. Journal of Management Information Systems, 7 (4), pp.27-50.
Desai, S.S.M. (1982), Economic history Of India. Himalaya Publishing House, Bombay.
Dia, M. (1996) Africa's management in the 1990s and beyond: Reconciling indigenous and transplanted institutions. World Bank, Washington, DC.
Dore, R. (1984). Technological self-reliance: Sturdy ideal or self-serving rhetoric. In Fransman and King (1984).
Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants of technological change. Research Policy, 11, pp. I47 -62.
Dosi, G., Freeman C., Nelson, R.R., Silverberg G., & Soete, L. eds. (1988). Technical change and economic theory. London: Pinter Publishers.
Dougherty, C.(1989). Thecosteffectivenessofnationaltrainingsystemsindevelopingcountries.PPRWorking Papers, WPS 171, Washington DC: world Bank.
Doyle, J.L. (1991). Problems with strategic information systems frameworks. European Journal of Information Systems. 1 (4), pp.27 3-280.
Drew, E. P. & F. Gordon Foster eds. (1994). Information technology in selected countries: Reports from Ireland, Ethiopia, Nigeria, and Tanzania. Tokyo. United Nations University Press.
Ducatel, K. & Miles, I. (1992)- Internationalisation of information technology services and public policy implications. World Development, 20(12), December, pp. 1843-57.
Dunn, J. (1978). West African states: Failure and promise. Cambridge: Cambridge University Press.
Dutta, S. (1994). Aligning it with the business: A comparative study of Two Banks. INSEAD Working Papers: 94/37/TM/SM, p.25.

E. Bekele (1996). Research and development: Problems and management in higher education institutions in Ethiopia with particular reference to Addis Ababa University. Proceedings of a conference on research training for countries with limited research capacity. Roskilde University Press.
Ead, M J (1989). Management strategies for information technology. Prentice Hall, New York.
Easton, G. (1992). Industrial networks: A review. In Axelsson and Easton (1992).
Economic/Commercial US Mission to Eritrea, March 24, 1998
Eicher, Carl K. (1992)- African agricultural development strategies. In F. Stewart, S. Lall, & S. Wangwe eds. Altenntive development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.
Eisemon, T. O. & Davis, C. H. (1993). Universities and scientific research capacity. In Ahmed Aqueil ed, Science and technology, policy for economic development in Africa. E.J.Brill: Leiden, New York, Koln
Eisenhardt, K.M. (1989), Building theories from case study research. Academy of Managem.ent Review, 14(4), pp. 532-550.
Elkington, J. & Shopley, J. (1988). The shrinking planet: U.S. information technology and sustainable development. Washington, D.C.: World Resource Institute.
El-Namaki (1979) Problems of management in d developing environment: The case of Tanzania North-Holland Publishing Company: Amsterdam, New York, and Oxford.
Enos, J.L. & Park, W. H. (1988). The adoption and diffusion of imported technology: The case of Korea. Croom Helm. London.
Enos, J.L. (1991). The creation of technological capability in developing countries. Pinter Publishers: London and New York.
Enos, J.L. (1994). In pursuit of science and technology in Sub-Saharan Africa: The impact of structural adjustment programmes. UNU/INTECH studies in new technologies and development, London, New York: Routledge.
Erbe, F S. (1981). Science and technology policy in Brazil: A survey of the literature. Latin American Research Review, 16 (1).
Erber, F.S. (l 978). Technological development and state intervention: A case study of the Brazilian capital goods industry. D.Phil. dissertation, University of Sussex.
Erber, FS. (1984). Technological dependence and learning revisited. Institute of Industrial Economics, University of Rio de Janeiro (mimeo).
Erber, F. S. (1990). Politica de informatica e politica industrial. Rio de Janeiro: IPEA.
Eritrea. Basic Education Statistics and Essential Indicators L995196, Ministry of Education, Asmara-Eritrea, 1996.
Eritrea: Basic Education Statistics and Essential Indicators 1996197, Ministry of Education, Asmara-Eritrea, November 1997.
Eritrea: Government-Development Partners Meeting, November 2, 1998, Denden Club, Asmara.
Eritrea: Internet, http://www3.sn.apc,org/africa/eritrea.htrn
Eritrean Profile, August 1, 1998
Eritrean Profile, March 21,1998
Eritrean profile, November 15, 1997
Eritrean Profile, vol. 3, No. 21
Eritrean Profile, vol. 4, No. 48, February 7, 1998
Eritrean Profile, vol. 6, No. 22, August 7, 1999
Ernest, D. (1985). Automation and world wide restructuring of the electronic industry: Strategic implications for developing countries. World Development, 13(3), March, pp.333-52.
ETE, E-mail in Eritrea, http://www.punchdown.org/rvb/emali/index.html

Etzkowitz, H & Brisolla, S. N. (1999). Failure and success: the fate of industrial policy in Latin America and South East Asia. Research Policy, 28, pp.33?-350.
Fajinzylber, F. (1979). The role of technology in planning the capital goods industry. UNIDO Symposium on Science and Technology in Development Planning, Mexico.
Fajinzylber, F. (1979). The role of technology in planning the capital goods industry. UNIDO Symposium on science and technology in development planning, Mexico.
Fei, J.C.H. (7977). Technology in developing country: The case of Taiwan. New Haven: Economic Growth Centre, Yale University.
Fiore, G. (1950). 200 pagine sull'Eritrea. Percotto Printing Press, Asmara.
Firebrace, J & Holland, S. (1985). Never kneel down Eritrea. The Red Sea Press, Trenton, New Jersey.
Fishlow, A. & Evans, P. eds. (1992), Brazilian informatics: A guide to the transition.
Flamm, K. (1987). Targeting the computer: Government support and international competition. Washington, D. C.: Brookings Institution.
Flarnm, K. (1989). The computer industry in industrialised economies: Lessons for the newly industrialising. World Bank Industry and Energy Department working Paper, Industry Series paper N I, Washington, DC. World Bank.
Fletcher, D. C. (1989). A note on recent developments in Sierra Leone information technology training. Information technology for development, 4(3).
Fong, Chan Onn (1991). Impact of new technology in the banking and insurance industries in Malaysia and Singapore. Geneva: ILO.
Forje, J.W. (1989). Science and technology in Africa. Akpan H. Ekpo, Harlow: Longman, p. 281.
Forje,J.W. (1993) The role and effectiveness of national science and technology policy-making bodies in Africa. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.J.Brill: Leiden, New York, Koln.
Forrest, T. (1992), The advance of African capital: The growth of Nigerian private enterprises. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.
Fortune, 1994, "Competitiveness: How U.S. companies stack up to now, April 18.
Frankel, M. (1955). Obsolescence and technical change in a maturing economy. American Economic Review, pp.296-319, quoted in C. Antonelli (1991).
Fransman, M. & King, K. eds. (1984). Technological Capability in the Third World. London: Macmillan.
Fransman, M. (1982a). Learning and the capital goods sector under free trade: The case of Hong Kong. World Development, 10(11).
Fransman, M. (1984a). Explaining the success of Asian NICs: Incentives and technology. IDS Bulletin (Sussex), 15 (2), April.
Fransman, M. (1984b), Promoting technological capability in the capital goods sector: The case of Singapore. Research Policy, t3, pp.33-54.
Fransman, M. (1984c). Some hypotheses regarding indigenous technological capability and the case of machine production in Hong Kong. In Fransman and King (1984).
Fransman, M. (1984d). 'Technological capability in the Third World: An overview. In Fransman and King (1984).
Fransman, M. (1986). Technology and Economic Development, Brighton: Wheatsheaf Books.
Fransman, M. ed. (1982b). Industry and Accumulation in Africa, London: Heinemann.
Fransman, M. ed., (1986). Machinery and economic development London: Macmillan,
Freeman, C & Perez, C. (1986). The diffusion of technical innovation and changes of techno-economic paradigms. Paper prepared for the conference on Diffusion of Innovation at Venice, DAEST, March.

Freeman, C. & Soete, L. Eds. (1990). New explorations in the economics of technical change. Pinter Publishers Ltd., London.
Freeman, C. & Soete, L.L.G. eds. (1987). Technical change and full employment. Black well, Oxford.
Freeman, C. (1982). Economics of industrial innovation. Frances Pinter, London and MIT Press, Cambridge (2nd ed.).
Freeman, C. (1984). Keynes or Kondratiev? How can we get back to full employment? In P. Marstrand ed. New technology and the future of work and skills. London: Frances Pinter.
Freeman, C. (1987). Technology policy and economic performance: Lessons front Japan. Pinter Publishers, London and New York.
Freeman, C. (1988). Information technology and the new economic paradigm. In H.Schutte ed. Strategic issues in information technology: International implications for decision makers. Published by Pergamon Infotech Ltd., Maidenhead, Berkshire, England.
Freeman, C. (1988). Japan: anew national system of innovation. in G. Dosi et al. Eds. Technical change and economic theory. London: Pinter.
Freeman, C. (1990). Technical innovation in the world chemical industry and change of technological economic paradigm. In Freeman & Soete eds. New explorations in the economics of technological change. Pinter Publishers, London and New York.
Freeman, C. (1990). The economics of innovation. Edward Elgar Publishing Ltd., England.
Freeman, C., Clark, J. & Soete, L. (1982). Unemployment and technical innovation. London: Frances Pinter.
Friedman, A.L. (1993). The information technology field: Using fields and paradigms for analysing technological change. University of Bristol Economics Working Paper: 931347 , March 1993, p. 33.
Fripp, J. (1991). Examples and implications of strategic information systems. In E. Sutherland & Y. Morieux eds. Business Strategy and Information Technology. London and N.Y.: Routledge , pp. 111-30.
Frischtak, C. (1986). National policies for developing high technology industries: International comparisons: Brazil. In F. W. Rushing and C. G. Brown eds. National policies for developing high technology industries: International comparisons. Westview special studies in science, technology, and public policy series, Boulder, Colo., and London: Westview Press, pp. 31-69.
Frischtak, C (1992). Banking automation and productivity change: The Brazilian experience. World Development, 20 (12), December, pp. 1769-84.
Furtado, C (1963). The economic growth of Brazil: A survey from colonial to modern times. University of California Press, Berkeley and Los Angeles,
Gahan, E. (1992) Computers for industrial management in Africa: An overview of issues. Industry and Development, No.31, UMDO, Vienna.
Gaillald, J. & Waast, R. (1993). The uphill emergence of scientific communities in Africa. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.J.Brill: Leiden, New York, Koln, 1993.
Gaio, F. (1992). Software strategies for developing countries: Lessons from the international and Brazilian experience. In H. Schmitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons from the Brazilian electronics and automation. Routledge, London and New York.
Ganzhorn, K. (1991) Infrastructural requirements of information technology and small and medium enterprises. In A. S. Bhalla ed. Small and medium enterprises: Technology policies and options. Forward by Serio C. Trinidad, Contributions in Economics and Economic History, No. 124, Westport, conn. And London: Greenwood Press on behalf of the United Nations Centre for Science and Technology for Development, pp. 233-45.
Garson, B. (1988). How computers are transforming the office of the future into the fact of the past. Simon and Schuster, New York.

Georghiou, L, et al (1986). Post-innovation performance: Technological development and competition. London: Macmillan Press.
Ghani, E. (1989). Trade regime and trade performance of Mauritius in the 1980s. Mimeo (Oxford).
Ghosh, A. (1992). Introduction. In A. Ghosh, K. K. Subrahmanian, M. Eapen & H. A. Drabu eds. Indian industrialisation structure and policy issues. Delhi Oxford University Press, Oxford - New York.
Ghymu, K.L (1980). MNEs from the Third World. Journal of International Business Studies, Autumn.
Gialini, O. ed. (1987). The emerging service economy. Services World Economy Series, Oxford: Pergamon Press.
Gibson, L. (1988). The long term impact of the telecommunication industry and information technology. In I. Orishimo, G. J. D. Hewings, P. Nijkamp eds. Information Technology: Social and spatial perspectives. Proceedings of an international conference on information technology and its impact on the urban-environmental system held at the Toyohashi University of Technology, Toyohashi, Japan, November 1986, lecture notes in Economics and Mathematical Systems series, Vol.3l5, N.Y.: Springer, pp. 107-24.
Gibson, R. (1998). Informatics diffusion in South American developing economies. Journal of Gktbal Information Management, 6(2), pp" 35-42.
Gilbert, A.L. (1990) Information technology transfer: The Singapore strategy. In M. Chatterji ed. Technology transfer in the developing countries. N.Y.: St. Martin's Press, pp. 320-34.
Girvan, N.P. & Marcelle, G. (1990). Overcoming technological dependency: The case of electric arc (Jamaica) Ltd.. A small firm in a small developing county. World Development, 18 (1), pp.91-107.
Girvan. N.P. (1986). Technology and management in the Caribbean. The Manager, Kingston, Jamaica, No. 12.
Glenn, P.A. (1993). Information technology in a global economy. Computational Economics, 6(2), May, pp. 107-14.
Godfrey, M.(1985).Trade and exchange rate policy in Sub-Saharan Africa. IDS Bulletin, 16 (3),pp.31-8.
Gold, B. (1988). Charting a course to superior technology evolution. Sloan Management Review, 30(1), fall.
Gore, M. S. & Chitnis, S. (1979). Societal expectations from science and technology. In H.N. Sethna, R. Chidambalam, B.V. Subbarayappa & B.M. Udgaonkar eds. Proceedings of the international Seminar on Science, Technology and Society in Developing Countries, Bombay, November 1979.
Goulet, D. (1979). Can values shape Third World technology policy? Journal of International Affairs, 33, Spring.
Government of the State of Eritrea, 1994, 'Macro Policy', Asmara, November 1994.
Government of the State of Eritrea, 1998, 'National Economic Policy Framework and Program for 1998-2000', Asmara, April 1998.
Greenwald, B. C. & Stiglitz, J. E. (1986). Externalities in economies with imperfect information and incomplete markets. Quarterly Journal of Economic s, I 0 1, pp. 229 -264.
Grieco, J. M. (1985). Between dependency and autonomy: India's experience with the international computer industry. In T. H. Moran ed. Multinational corporations: the political economy of foreign direct investment. Lexington, Mass., and Toronto: Heath, Lexington Books, pp. 55-81
Grossman, C. M. (1990). Promoting new industrial activities: A survey of recent arguments and evidence. OECD economic Studies, 10(14), Spring, pp. 87-125.
Gulhati, R. & Sekhar , U. (1987). Industrial strategy for late starters: The experience of Kenya, Tanzania, and Zambia. World Development, 10(11), pp.949 - 97 2.
Gulhati, R. (1989). Trade policy reforms in Sub-Saharan Africa. In H. W. Singer & S. Sharma eds. Growth and external debt management. New York: St. Martin's Press.
Haddas Eritrea. 28 October 1997

Hakansson, H. ed. (1987). Industrial technological development: A net work approach. Croom-Helm: London,

Hann, N., et al., 1990, "Development in the information age: An evolving role for the World Bank", Mimeo (Washington DC: World Bank, November)

Hanna, N. & Boyson, S. (1993). Information technology in World Bank lending: Increasing the development impact World Bank Discussion papers, No. 206, Washington, D.C, 'World Bank.

Hanna, N. & Boyson, S. (1993). Information technology in World Bank lending: Increasing the development impact. World Bank Discussion papers, No. 206, Washington, D.C.: World Bank.

Hanna, N. & Schware, R. (1990). Information technology in World Bank financed projects. Information Technology for Development, 5(3).

Hanna, N. (1991). The information technology revolution and economic development. Washington, D.C.: World Bank.

Hanna, N. (1994). Exploiting information technology for development: A case study of India. Discussion Papers , No. 246, Washington, D.C.: World Bank, 1994.

Hanna, N. (1994). Exploiting information technology for development: A case study of India. Discussion Papers, No 246, Washington, D.C.: World Bank, 1994.

Hanna, N., Guy, K. & Arnold, E. (1995). The diffusion of information technology: Experience of industrial countries for developing countries. Washington, D.C.: World Bank.

Hanson, J. & Narula, U (1990). New communication technologies in developing countries. Hillsdale, N.J.: L. Erlbaum Associates.

Hardy, C. (1992). The prospects for intra-regional trade growth in Africa. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.

Hartog, C. & Herbert, M. (1986). 1985 opinion survey of MIS managers: Key issues. MIS Quarterly, December, pp. 35 l-361.

Havnevik, K. (1986). Tanzania - country study and Norwegian aid review. Centre for Development Studies, University of Bergen.

Havnevik, Skarstein K. R., & Wangwe, S. (1985). Small scale sector study: Tanzania. SIDA, Stockholm.

Heeks, R, (1999a). Information Age Reform of the Public Sector: The Potential and Problems of IT for India. Information Systems for Public Sector Management, Working Paper Series, Working Paper no. 6, Published by Institute for Development Policy and Management, University of Manchester, Precinct Centre, Manchester.

Heeks, R. (1998b). The Uneven Profile of Indian Software Exports. Development Informatics, Working Paper Series, Working Paper no. 3, Published by Institute for Development Policy and Management, University of Manchester, Precinct Centre, Manchester.

Heeks, R. B. (1991). State policy and the development of the Indian software industry. Ph.D. thesis, Open University, Milton Keynes.

Heitzman, J. (1990). Information systems and development in the Third World. Information Processing and Management, 26 (4).

Helleiner, G. K. (1992). The IMF, the World Bank and Africa's adjustment and external debt problems: An unofficial view. World Development, 20 (1), pp.779-792.

Heuderson, J. & Ventakraman, N. (1992). Strategic alignment: A model for organisational transformation through information technology. In T. Kochan & M, Unseen eds. Transforming Organisation Oxford University Press, N.Y., pp. 97-116.

Heng, Toh Mun & Low, L. (1990). The economic impact of the information sector in Singapore. Economic of Planning, 23 (1), pp. 5 l -70. Flerbert-Copley, B. (1990) Technical change in Latin American manufacturing firms: Review and synthesis. World Development, 18(11), pp. 1457-1468.

Herrera, A. (1973). Social determinants of science in Latin America: Explicit science policy and implicit science policy. In Cooper (1973).

Hewitt, T (1988) 'Employment and skills in the electronics industry' The case of Brazil. D.Phil. Thesis, University of Sussex.

Hewitt, T. (1992) Employment and skills in the Brazilian electronics industry. In H. Schmitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons from the Brazilian electronics and automation Routledge, London and New York.

Hicks, E K., Nsubuga, N., Tidjani, B., Rahamato, D & Mekonen, T. (1997). The flow of information: Social and economic science in Sub-Saharan Africa. Research Report No. 199'7-02, university of Groningen, Faculty of Management and Organisation, The Netherlands.

Hicks, J. (1981). The mainspring of economic growth. The American Review 1 (6), pp.23-32.

Hill, S. (1987). Basic design principles for national research in developing countries. Technology in Society, .9, pp.63-73.

Hirschman, A O. (1982). The rise and decline of development economics. In M. Gersovitz, C. F. Diaz-Alejandro, G. Ranis & M. Rosenzweig eds. The theory and experience of economic development. Essays in honour of Sir W. Arthur Lewis. London: Allen & Unwin.

Hobday, M. (1990). Telecommunications in developing countries: The challenge from Brazil London and New York Routledge.

Hobday, M. (1995). Innovation in East Asia: The challenge to Japan. Edward Elgar Publishing, England.

Hoffman, K. & Rush, H. (1980). Microelectronics industry and the Third World. Future, Aug., pp. 289-301.

Hoffman, K. (1991). Commission of the European Communities, Science Research and Development, SAST Project No. l, Country Report on India, (ECSC-EEC-EAEC) Brussels-Luxembourg.

Hon, -Wong -Seng, (1992). Exploiting information technology: A case study of Singapore. World Development, 20 (12), December, pp. l817-28.

Hosieh, Charng-Horng & KonWang, Sun-Perng (1997). The development of capability for tackling R&D issues in a small company: A case of a CNC-controller manufacturer in Taiwan. Int. J. Technology Management, 13 (5/6), pp. 71 -587.

Hou, Chi-Ming & Gee, -San (1993). National systems supporting technical advance in industry: The case of Taiwan. In R. R. Nelson ed. National innovation systems: A comparative analysis. New York Oxford, Oxford University Press.

Howell, J., & Higgins, C. (1990). Champions of change: Identifying, understanding and supporting champions of technological innovations. Organisational Dynamics, Summer, pp. 40-56.

Hsia, R. (1979).Technological change, trade promotion and export-led industrialisation (with reference to Hong Kong and South Korea) Bangkok: ILO-ARTEP, Asian Employment Programme Working Paper WPII-2,

http://www.sas.uoenn.edu/African-StudieVECA./nan2a.html

http://www3. sn.apc.org/africa

Huber, G.P. (1990). A theory of the effects of advanced information technologies organisational design, intelligence and decision making. Academy Management Review, 15 (1), January, pp. 47-71.

Hughes, H. (1980). Achievements and objectives of industrialisation. In J. Cody, H. Hughes & D. Wall eds. Policies for industrial progress in developing countries. A study sponsored by UMDO and World Bank. Published for the World Bank. Oxford University Press.

Huppes, Tj. (1990). Information technology for organisational effectiveness: The challenge of the 1990s. International Journal of Information Resources Management , pp. 4-12.

Hutchinson, P. (1987). The installation of microcomputer system in Somalia. Information Technology for Development, 2(3).

Hyden, G. (1983). No short cuts to progress: African development management in perspective Heineman Educational Books, London,
Hyman, -Eric L. (1993). The design of micro-projects and macro-policies: Examples from three appropriate technology projects in Africa. In A. Ahmed ed. Science and technology policy for economic development in Africa. E. J. Brill: Leiden, New York, Koln.
IDRC (1981). Priorities for science and technology policy in Africa: Report of a seminar held at the University of Ife, Ile-Ife, Nigeria, 3-6 December 1979', IDRC-162e. Report of the seminar sponsored by the International Development Research Centre and the Economic Commission for Africa, Ottawa, Ont: International Development Research Centre, p. 32.
IDRC, Regional office for Southern Africa (1993). Towards o Science and Technology Policy for a Democratic South Africa., Mission report, Vol.3, Johannesburg: IDRC, p. 131.
Ikeo, K. (1992). Information technology and the restructuring of banking services. Bank of Japan Monetary and Economic Studies, 10(1) February, pp.45-64.
ILO Advisory Mission to Eritrea (1995). Foundations for sustained employment in Eritrea. Addis Ababa.
IMF (1997). Hong Kong, China growth, structural change, and economic stability during transition. Jhon Dodsworth & Dubravko Mihaljek (Occasional Paper No. 152).
InfoTech (1992). India's software & services export potential & strategies. InfoTech: Parsippany, N. J.
Infante, Eldo (Dott.) (1947). Rassegna technica delle industrie Eritree. Asmara.
Ito, Y. (1988) Global communication and cultural identity: An East Asian perspective. In H Schutte ed. Strategic issues in information technology: international implications for decision makers. Published by Pergamon Infotech Ltd., Maidenhead, Berkshire, England.
Ito, Y. (1990). The social and cultural impacts of information technology. In F. Meyer- Krahmer, J. Muller & B. Preissl eds. Information technology: Impacts, policies and future perspectives. Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp.27 -39.
ITU, African Telecommunication Indicators 1996.
Jacobsson, S. (1981). Electronics and the technology gap - The case of numerically controlled machine tools. Research Policy Institute, University of Lund.
Jacobsson, S (1984). Industrial policy for the machine tool industries of South Korea and Taiwan. IDS Bulletin (Sussex), 15(2).
Jacobsson, S. (1986). Electronics and industrial policy: The case of computer controlled lathes. Volume 5 in I Walter ed. World industry studies. Allen & Unwin: London,
Jacobsson, S. (1993). The length of the infant industry period: Evidence from the engineering industry in South Korea. World Development, 21(3), pp, 407419.
Jaconsson, S (1992). Sweden's technological system and future development potential: The case of electronics and computer technology. Working Paper, Dept of Industrial Management and Economics, Chalmers University of Technology, Goteborg.
Jamal, V &.Weeks, J. (1993). Africa misunderstood: or whatever happened to the rural-urban gap? Basingstoke (etc.): MacMillan (the Macmillan series of ILO studies) Press Ltd., London, UK.
James, J. (1986). Bureaucratic, engineering and economic Man: Decision making for technology in Tanzania's state-owned enterprises. In S. Lall & F. Stewart eds. Theory and reality in development. London Macmillan.
James, J. (1995). The state, technology and industrialisation in Africa. Basingtoke: Macmillan: New York, N Y.: St Martin's Press.
Jamison, A. (1991). National styles in technology policy: Comparing the Swedish and the Danish state programmes in microelectronics/information technology. In U. Hilpert ed. State Policies and Techno-Industrial Innovation. London and N.Y.: Routledge, pp.315-21 .

Jansson, H. (1982). Inter firm linkages in a developing economy: The case of Swedish firms in India. Doctoral Dissertation, Uppsala University, Department of Business Administration, Liber Tryck: Stockholm.

Jensen, M, (1999). African Internet status July 1999. Http://www3.snapc.org/africa./afstat.htm

Johanson, J. & Mattson, I-.G. (1987). Inter-organisational relations in industrial systems: A network approach compared with the transaction-cost approach. International Studies of Management and Organisations, Vol. XVII, No. 1, pp.34-48.

Johnson, B.B. & Marcovitch, J. (1994), Uses and applications of technology futures in national development: The Brazilian experience. Technological Forecasting and Social Change, 45, pp. 1-30.

Jolrnson, C. (1982). MITI and the Japanese miracle: The growth of industrial policy. 1925-1975, Stanford University Press.

Jones, Leroy P. & Sakong, L. (1980). Government, business and entrepreneurship in economic development: The Korean case. Cambridge , MA: Harvard University Press.

Jonsson, S. (1987). Limits of information technology for facilitating organisational learning. In J. M. Pennings & A. Buitendam eds. New technology as organisational innovation: The development and diffusion of microelectronics. Ballinger series on The Management of Innovation and Change, Cambridge, mass Harper and Row, Ballinger, pp.2l7-34.

Joseph, K. J. (1992) The growth performance of the electronics industry in India and South Korea, A comparative analysis. In A. Ghosh, K. K. Subrahmanian, M. Eapen & H. A. Drabu eds. Indian Industrialisation. Structure and policy issues. Delhi Oxford University Press, Oxford, New York.

Jowett, P. & Rothwell, M. (1986). The Economics of information technology. New York: St. Martin's Press.

Jussawalla, M. & Dworak, S. (1989). The impact of telematics on financial intermediaries and market interdependencies. In M. Jussawalla, T. Okuma & T. Araki eds. Information technology, and global interdependence. Foreword by Kazuo Ogura, Contributions in economics and economic history series No 83, Westport, Conn. And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of international Affairs, pp. 85-101.

Jussawalla, M. (1989). Overview of thoughts expressed on information technology and economic interdependence. In M. Jussawalla, T. Okuma & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura, Contributions in economics and economic history series No. 83, Westport, Conn. And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp. 3-8.

Jussawalla, M., Okuma, T. & Araki, T. eds. (1989). Information Technology and Global Interdependence, Foreword by Kazuo Ogura, Contributions in Economics and Economic History series No. 83, Westport, Conn. And London, Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs.

Kam, W.P. (1991). Technological development of local firms in developing countries through subcontracting linkage with multinational corporations: Evidence from Singapore. Proceedings from the 7th LM.P. Conference held in Uppsala, September 1991.

Kamel, Sherif (1995). IT diffusion & socio-economic change in Egypt. Journal of Global Information Management, 3(2), Spring, pp. 4-16.

Kamien, M. I. & Schwartz, N. L. (1982). Market structure and innovation. Cambridge University Press.

Kaplinsky, R.(1984). Changing patterns of industrial location and international competition: The role of TNCs and the impact of microelectronics. New York: United Nations Centre on Transnational Corporations.

Kaplinsky, R. (1985). Electronic-based automation technologies and the onset of systemofacture: Implications for the Third World industrialisation. World Development, 13(3), pp.423-439.

Kariuki, M., Muthigani, E,K., Ngángá, J.M. & Nguli, S. K. (1988). Kenya: National information and informatics policy Paper presented at the National Information and Informatics Policies in Africa: Report and Proceedings of a Regional Seminar, Addis Ababa, Ethiopia, 28 Nov. - 1 Dec. 1988.
Katz, J. (1978). Technological change, economic development and extra regional relations in Latin America Buenos Aires: IDBIECLA^INDP/IDRC Regional Program of Studies on Scientific and Technological Development in Latin America, Working Paper 30.
Katz, J. (1984). Domestic technological innovations and dynamic comparative advantages: Further reflections on a comparative case study program. Journal of Development Economics, 16(112), Sept-Oct , pp. 13-37.
Katz, L (1984). Technological innovations, industrial organisation and comparative advantages of Latin American metal work industries. In Fransman and King (1984).
Katz, J M. (1987). Domestic technology in LDCs: A review of research findings. In J. M. Katz ed. Technology generation in Latin America manufacturing industries. New York: St. Martin's Press, pp. 13-55.
Kaul, M., Patel, N & Shams, K. (1987). Trends in IT application in Asian government systems. Kuala Lumpur: Asia and Pacific Development Centre.
Keen, P. (1991). Shaping the future: Business design through information technology Harvard Business School Press, Boston.
Keirstead, B. G. (1948) The theory of economic change. Macmillan, Toronto.
Kelkar, V & Varadarajan, K. (1990). India's computer industry: Perspectives and options for latecomer strategies. Paper presented to the OECD development Centre Research Project on Technological Change and the Electronics Sector. Paris, May 1989.
Kelkar, V. (1991). India's information economy: Role, size and scope. Economic and Political Weekly, 26(31), February, pp. 21 53 -21 61.
Kellion, T. (1996). The Eritrean Economy in historical perspective. Eritrean Studies Review, 1 (1), Spring, pp 91- 118.
Kelly, M. J. F. (1987). Computer utilisation and staffing in Zambia: A survey conducted in late 1986. Information Technology for Development, 2(4).
Kerr, C. (1983). The future of industrial societies. Cambridge: MA: Harvard University Press.
Kilby, P. (1969). Industrialisation in an open economy: Nigeria 1945-66. Cambridge University Press: London.
Killick, T. (1978). Development economics in action: A study of economic policies in Ghana. London: Heinemann.
Kinr, L. & Lee, J. (1987). Korea's entry into the computer industry and its acquisition of technological capability. Technovation, 6 (2), pp. 277-293.
Kirn, L. & Dahlman, C. J. (1992). Technology for industrialisation: An integrative framework and Korea's experience. Research Policy, 21, pp. 437-452.
Kim, L. (1980) Stages of development of industrial technology in a developing country: A model. Research Policy, 9, pp, 254-277 .
Kim, L. (1988). Technology policies and strategies for developing countries: Lessons from Korean experience. Technology Analysis &Strategic Management, 10(3), pp. 311-322.
Kim, L. (1993). National System of industrial innovation: Dynamics of capacity building in Korea. In R. R. Nelson ed, National innovation systems: A comparative analysis. New York Oxford, Oxford University Press.
Kim, Youngbae, Lee, B. & Lim, Y. (1999). A comparative study of managerial features between public and private R&D organisations in Korea: managerial and policy implications for public R&D organisations. Int. J. Technology Management, 17(3), pp.281-11L

Kirn,Y.C. & Kwon, I K. (1971). The utilisation of capital and the growth of output in a developing economy. Journal of Development Economics, 4(1971), pp.265-278.

Kim,Y.C & Kwon, LK. (1977). The utilisation of capital and the growth of output in a developing economy. Journal of Development Economics, 4, pp.265-278, North Holland Publisher.

Kirkpatrik, C., Lee, N. & Nixson, F. (1984). Industrial structure and policy in less developed countries. Allen & Unwin: London.

Kitahara, Y. (1988). Telecommunications in an advanced information society: A Japanese perspective. In I. Olishimo, C. J, D. Hewings & P. Nijkamp eds. Information technology: Social and spatial perspectives. Proceedings of an international conference on information technology and its impact on the urban-environmental system held at the Toyohashi University of Technology, Toyohashi, Japan, November 1986, lecture notes in Economics and Mathematical Systems series, Vol. 315, N.Y.: Springer, pp.39-46.

Kleinrnan, D L (1994).LaycrsofinflucnceBusincssandgonesisoftheNationalscienceFoundation, science Technology & Human Values, 79 (3), pp. 259-282.

Knight, J. (1992). Public enterprises and industrialisation in Africa. In F. Stewart, S. Lall & S. Wangwe eds. Alternative Development strategies in Sub-Saharan Africa, Macmillan Press Ltd., London.

Koda, G.R., Bilal, M.C. & Sawe, D.A. eds. (1987). Seminar on the Contribution of Informatics to Economic Development, Arusha, Tanzania.

Komatsuzaki, S. (1990). Future world markets for information technology products: Comment. In F. Meyer-Krahmer, J, Muller & B. Preissl eds. Information technology: Impacts, policies and future perspectives. Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp.1 94-96.

Kostecki, M. M. (1989). Electronic trade policies in the 1980s. Journal of World Trade, 23 (1).

Kraemer, K.L. & Dedrick, J. (1994). Payoffs from investments in information technology: Lessons from the Asia-Pacific Region. World Development, 22(12), December, pp. L92I-31.

Kunene, P.E (1986). An over view of informatics in Swaziland. Proceedings of the Southern African workshop on informatics for development. Victoria Falls, Zimbabwe, May.

Kunreuther, H. (1986), The impact of technology on the insurance industry: Discussion. In G. Faulhaber, E. Noam & R. Tasley eds. Services in transition: The impact of information technology on the service sector. Cambridge, Mass.: Harper & Row, Ballinger, pp. 44-48.

Kuznets, P. W. (1988). An East Asian model of economic development: Japan, Taiwan and South Korea, Economic Development and Cultural Change,36(3), pp. S 1 1-43.

Laage-Hellman J., 1989, Technological Development in Industrial Networks, Doctoral Dissertation Uppsala University.

Lacke, J.C. (1995) Information technology, employee participation and the de-skilling thesis. Ph.D. dissertation University of New Hampshire.

Lall, S. & Teubal, M. (1998). Market-stimulating technology policies in developing countries: A framework with examples from East Asia. World Development, 26(8), pp.1369-1385.

Lall, S. (1984). Exports of technology by newly industrialising countries: An overview. World Development, 12(5/6), pp.47I-80.

Lall, S. (1987). Learning to industrialise. The Macmillan Press, London.

Lall, S. (1989) Human resources development and industrialisation, with special reference to Sub-Saharan Africa. Journal of Development Planning, 19, Summer, pp, 128-48.

Lall, S. (I 990). Building industrial competitiveness in developing countries. Paris: OECD Development Centre.

Lall, S. (1992). Structural problems of African industry. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.

Lall, S. (1992). Technological capability and industrialisation. World Development, 20 (2), pp. 165-1 86.

Lalor, S.E. (1986). Overview of the micro-electronics industry in selected developing countries. Industry and Development, No. 16, UNIDO, Vienna
Lamberton, D. (1994). The information revolution in the Asian-Pacific Region. Asian-Pacific Economic Literature, 8(2), November, pp. 31-57.
Langdon, S. (1984). Indigenous technological capability in Africa: The case of textile and wood products in Kenya. In Fransman and King eds. (1984). Macmillan: London and Basingstoke.
Lanvin, B. ed, (1993). Trading in a new world order: The impact of telecommunications and data services on international trade in services. Atwa.ter Series on the World Information Economy, 3, Boulder and Oxford: Westview Press.
Lee, Chong-Ouk (1988). The role of the government and R&D infrastructure for technology development. Technological Forecasting and Social Change,33, pp. 33-54.
Lee, J.; Bae, Z.-T. & Choi (1988). Technology development processes: A model for a developing country with a global perspective. R&.D management, 18, pp. 235-250.
Levian, G. (1989). Uganda, technical report: Proposals for the computerised information system to be implemented in the Planning Unit of the Ministry of Industry and Technology. (IOiR.89, 16 February).
Lewis, W. Arthur (1965), Politics in West Africa. New York: Oxford University Press.
Lichtenberg, F. R. (1993). The output contributions of computer equipment and personnel: A firm level analysis. Working Paper No. 4540, Cambridge, MA: National Bureau of economic Research, November.
Lichtenberg, F. R. (1995). The output contributions of computer equipment and personnel: A firm-level analysis. Economics of Innovation and New Technology, 3(3-4), pp 201-17.
Liedholm, C. (1992). Small-scale industries in Africa: Dynamic issues in the role of policy. In S. Lall, F. Stewart & S. M. Wangwe Eds. Alternative development strategies for African development. London: McMillan.
Linda Low, Mun Heng Toh, Teck Wong Soon & Kong Yam Tan (1992). Challenge and response: Thirty years of the economic development board. Times Academic Press, Singapore.
Linder, J. (1989). Integrating organisations where information technology matters. Harvard University, D.B.A.
Little, I. M, D., 1982, Economic Development - Theory, Policies and International Relations, Basic Books, New York.
Little, I.M.D. (1979). The experience and causes of rapid labour intensive development in Korea, Taiwan, Hong Kong and Singapore and the Possibility of Emulation. Bangkok: ILO-ARTEP.
Liu, Paul K. C. (1992). Science, technology and human capital formation. In G. Ranis ed. Taiwan: from developing to mature economy. Westview Press: Boulder- San Francisco , Oxford.
Loh, P, Marshall, C. & Meadows, C. J. (1998). High-tech/Low-tech: Appropriate technologies for developing nations. Journal of Global Information Management, 6(2), pp.5-12.
Lomax, D. (1990). Investment criteria for Bankers. Paper presented to Africa Telecom 90 Conference, Harare, Zimbabwe. December 5.
Loveman, G. W. (1986). The productivity of information technology capital: An econometric analysis. Mimeo, Department of Econometrics, MIT.
Loveman, G. W. (1988). An assessment of the productivity impact of information technologies. MIT Management in the 1990, Working Paper No. 88-054, July.
Loveman, C. W. (1994). An assessment of the productivity impact of information technologies. In T. J. Allen & M. S. Scott Morton eds. Information technology and the corporation of the 1990s: Research studies. New York Oxford, Oxford University Press.
Lundvall, B.-A. (1985). Product innovation and user-producer interaction. Aalborg University Press, Aalborg. MacBean, A (1966). Export instability and economic development. Cambridge, Mass.: Harvard University Press.

Macdonald, S. (1983). Technology beyond machines. In S. MacDonald, D. McL.. Lamberton & T. Mandeville eds. The trouble with technology: Exploration in the process of technological change. New York: St. Martin's Press.
Madison, T, N. Lower (1992). Strategic alignment: A model for organisational transformation through information technology: Commentary. In T. A. Kochan & M. Useem eds. Transforming organisations. N.Y., Oxford University Press, pp.116-17.
Malerba, F. (1992). Learning by firms and incremental technical change. Economic Journal, 10(2), pp.845-59.
Malerba, F. (1985). The semiconductor business. London: Frances Pinter.
Manning, R. L., Stephenson, M.K. & Todd, J.D. (1985). Information technology in the insurance industry: A forecast of utilisation and impact Journal of Risk and Insurance, 52(4), December 1985, pp. 7 1l-22.
Martinons, M.G, (1993), Cultivating the strategic use of information technology: Lessons from Hong Kong. Technology Analysis & Strategic Management, 5 (2), pp. 179-186.
Maxwell, P. (1982). Steel plant technological development in Latin America - A comparative study of the selection and upgrading of technology in plants in Argentina, Brazil, Colombia, Mexico and Peru. Buenos Aires: IDB/ECLA Research Program on Scientific and Technological Development in Latin America, Working Paper 55.
Mazrui, A.A. (1988). Is Africa decaying? The view from Uganda. In H. B. Hansen & M. Twaddle eds.. Uganda Now: Between decay and development. London: James Currey.
Mckendck, D. (1992). Use and impact of information technology in Indonesian commercial banks. World Development, 20(12), December, pp. 1753-68.
Meier, G M. & Steel, W.F, eds. (1989). Industrial adjustment in Sub-Saharan Africa. Published for the World Bank, Oxford University Press.
Melody, W.H. (1990). Future world markets for information technology. In F. Meyer- Krahmer, J. Muller & B. Preissl eds. Information technology: Impacts, policies and future perspectives. Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp. 175-80.
Menon, V. (1989). Telecommunications and development: The case of India. In M. Jussawalla, T. Okuma & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura, Contributions in Economics and Economic History series No. 83, Westport, Conn, And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp.28l-88
Metcalfe, J. S. (1986). Technological innovation and competitive process. In P. Hall ed. Technology, innovation and economic policy. New York: St. Martin' s Press, pp. 35-64.
Mey, H (1989). The impact of information technology on international financial flows. In M. Jussawalla, T. Okuma & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura, Contributions in Economics and Economic History series No. 83, Westport, Conn. And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp. 102-08.
Meyer-Stamer, J. (1990). Unconventional technology transfer and high tech development: the case of informatics in Newly Industrialising Countries. In M. Chatterji ed. Technology transfer in developing countries. New York: St Martin's Press, pp. 281-90.
Michell, T. (1984) Administrative traditions and economic decision making in Korea. IDS Bulletin, 15 (4), pp. 40-48
Michelsen, H. & Shapiro, D. eds. (1998). Strengthening the role of universities in the national agricultural research systems in sub-Saharan Africa: Cotonou. Benin, 17-21 November 1997.
Middleton, R. (1995). Annual review of information technology developments for economic and social historians, 1994. Economic History Review, 48(2), May, pp. 37 0 -9 5.

Miller, J. & Ddoyle, B. (1987). Measuring the effectiveness of computer-based information systems in the financial service sector, MIS Quarterly, March.

Ministry of Agriculture Early Warning and Food Information Unit: Strategy Proposal and Work Plan, 1997.

Ministry of Trade and Industry, 1998, 'Results of the survey of Eritrea's Manufacturing Industries, 1992-1996' , Statistical Bulletin No. 1, Asmara, May 1998.

Mitsugi, M (1990). Production oriented information technology policy in Japan and Europe: Comment. In F. Meyer-Krahm, J. Muller & B. Preissl eds. Information technology: Impacts, policies and future Perspectives. Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp. 88-95.

Mkandawire, T. (1988). Comments on democracy and political instability. Africa Development, vol. XII, No. 3, p. 83.

Mlolwa, N. & Sawe, D (1988). Policy-makers' and planners' views on information/informatics policy in Tanzania. Paper presented at the National Information and Informatics Policies in Africa: Report and Proceedings of a Regional Seminar, Addis Ababa, Ethiopia, 28 Nov.-I Dec. 1988.

Mody, A. & Dahlman, C. (1992). Performance and potential of information technology: An international perspective. World Development, 20(12), December, pp. 1703- I 9.

Mody, A. (1987). Information industries: The changing role of newly industrialising countries. Technology and Government policy in telecommunication and computers, Washington, D. C.: Brookings Institute.

Mody, A. (1989). Institutions and dynamic comparative advantage: Electronics industry in South Korea and Taiwan Mimeo, Washington, D, C.: World Bank.

Moreira, M.M. (1995). Industrialisation, trade and market failures: The role of government intervention in Brazil and South Korea. St. Martin's Press, New York.

Morieaux, Y. & Sutherland, E. (1988). The interaction between the use of information and organisational culture. Behaviour and Information Technology, 7 (2), pp. 205-213.

Morishima, M (1982). Why has Japan succeeded? Western technology and the Japanese ethos. Cambridge: Cambridge University Press.

Moussa, A. & Schware, R. (1992). Informatics in Africa: Lessons from World Bank experiences. World Development, 20 (12), December, pp. 17 37-52.

Mun Heng, Toh & Linda Low (1990). The economic impact of the information sector in Singapore. Economics of Planning, 23 (1), pp. 51-70.

Mun Heng, Toh & Linda Low (1993). The intelligent city: Singapore achieving the next lap. Technology Analysis & Strategic Management, 5 (2), pp. 186-201.

Mytelka, L. (1978). Licensing and technical dependence in the Andean Pact. World Development,6(4), pp.447-59.

Mytelka, L. (1992). Ivorian industry at the cross-roads. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.

Nabarro, D. et al ,1989, "Microcomputers in developing country programmers: valuable tools or troublesome toys? Experience from Uganda and Nepal", Information Technology for Development, Vol.4, No. 4

Ndamagi, C. (1988). A practitioner's point of view on national informatics policies in Tanzania. Paper presented at the National Information and Informatics Policies in Africa: Report and proceedings of a Regional Seminar, Addis Ababa, Ethiopia, 28 Nov.- 1 Dec. 1988.

Ndamagi, E. (1987). Information technology in government: The case of Tanzania. Paper presented at the Eastern and Southern African workshop on Information technology in government, Rusape, Zimbabwe, April 1987.

Ndebbio, J.E. Udo (1993). Science, technology and development in ECOWASI. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.I. Brill: Leiden, New York, Koln.

Nelson, R.& Winter, S.G (1977). In search of use full theory of innovation. Research Policy, 6, pp.36-76.
Nelson, R. R. & Langlois, R. N. (1983). Industrial innovation policy: Lessons from American history. Science, 219. Feb.
Nelson, R. R. (1980). Production sets, technological knowledge and R&D: Fragile and overworked constructs for analysis of productivity growth? American Economic Review, Papers and Proceedings, 70, pp.62-61.
Nelson, RR. ed. (1993). National innovation systems; A comparative analysis. Oxford University Press, New York- Oxford.
Nelson, R.R. Winter, S. C. & Schuette, H. C. (19?6). Technical change in an evolutionary model. Quarterly Journal of Economics, 90, pp. 90-1 I 8.
Neo, B S. (1989). Information technology for comparative advantage: A contingency approach. Ph.D. Dissertation, University of Pittsburgh.
Nicholls-Nixon, C.L.& Jasinski, D. (1995).The blurring of industry boundaries: An explanatory model applied to telecommunications. Industrial and Corporate Change, a (4), pp. 755-68.
Nilsson, J. S. (1995). Progress through knowledge. Paper for the International Conference on Donor Support to Development Oriented Research in Basic Sciences Organised by SAREC and Uppsala University, June 1995
Niosi, J., Hanel, P & Fiset, L. (1995). Technology transfer to developing countries through engineering firms: The Canadian experience. World Development, 23 (10), October, pp.1815-24.
North, D.C. (1990). Institutions, institutional change and economic performance. Cambridge University Press, Cambridge.
Nyong'o, P. A. (1988). Political instability and the prospect of democracy in Africa. Africa Development, XIII (1), p.72.
O'Connor, D. C. (1985). The computer industry in the Third World: Policy options and constraints. World Development, 13(3), March, pp. 311-32.
OECD (1980). Impact of multinational enterprises on national scientific and technical capacities: Analytical report.
OECD (1988) New Technologies in the 1990's: a socio-economic strategy.
OECD (1989) Information Technology and New Growth Opportunity.
OECD (I991) Technology and productivity: The challenge for economic policy. OECD, Paris.
OECD (1995). Information computer communication policy: Communications outlook. OECD: Paris.
OECD, 1993, Usage Indicators: A New Foundation for Information Technology Policies.
OECD, 1995, Information Computer Communications Policy: Information Technology Outlook.
Ogura, K. (1989). Information technologies and international relations: Foreword. In M. Jussawalla, T. Okuma, & T. Araki eds, Information Technology and Global Interdependence. Foreword by Kazuo Ogura, contributions in economics and economic history series No. 83, Westport, Conn. And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp. ix-xiii.
Ohiorhenuan, John F. E. & Poloamina, I. D. (1992). Building indigenous technological capacity in African industry: The Nigerian case. In F. Stewart, S. Lall & S. Wangwe eds. Alternative development strategies in Sub-Saharan Africa. Macmillan Press Ltd., London.
Okoye, G (1989).ANigcrianexperienceinofficeautomationproject.InJormationTechnologyforDevelopment 2(4).
Oshima, H T, (1988). Human resources in East Asia's secular growth. Economic Development & Cultural Change, 36 (3), pp. S 103-122.
Osterle, H. (1995). Business in the information age: Heading for new processes. Heidelberg and New York Springer.

O'Brien, R. (1992). Global financial integration: The end of geography. Chatham House Papers, N.Y.: Council on Foreign Relations Press, London: Royal Institute of International Affairs.
Pack, H. & Westphal, L. E. (1986). Industrial strategy and technological change: Theory versus reality. Journal of Development Economics, 21, pp. 87-128.
Pack, H. (1981). Fostering the capital goods sector in LDCs. World Development, 9(3), pp.227-50.
Pang, E.F. & Lim, L. (1977). The Electronics industry in Singapore, structure, technology and linkages. ER Research Monograph Series No, 7, Singapore: Chopman Enterprises.
Pankhurst, E.S. (1952). Eritrea on the eve, Woodford Green.
Parapak, J. (1988). Information technologies and developing countries: Implications for decision makers. In H Schutte ed. Strategic issues in information technology: International implications for decision makers Published by Pergamon Infotech Ltd., Maidenhead, Berkshire, England.
Parsons, G.L. (1983). Information technology: A new competitive weapon. Sloan Management Review, 2 (1), Fall, pp. 3-14.
Parthsarathi, A. (1978). Electronics in developing countries: Issues in transfer and development of technology Geneva. UNICTAD.
Perez, C. (1983). Structural change and the assimilation of new technologies in the economic and social system. Futures, I 5(4), October, pp.357 -7 5.
Perez, C. (1985). Microelectronics, long waves and world structural change: New perspective for developing countries. World Development, 13(3), pp. 441-63.
Perez, C. (1987). The new technologies: An integrated view. SPRU mimeo, University of Sussex, Brighton.
Petrie, H. (1991). Technology in and outside the home: Its effects on the provision of personal information for living. In J. Meadows ed. Information technology and the individual. London: Pinter, distributed by Columbia University Press, N.Y., pp. 119-37.
Petrie, H. (1991). Technology in and outside the home: Its effects on the provision of personal information for living. In J. Meadows ed. Information technology and the individual. London: Pinter, distributed b Columbia University Press, N.Y., pp. 119-37.
Phamoise, L.L. (1986). The status of informatics technology in Lesotho - Past, present and future. Proceedings of the Southern African workshop on informatics for development. Victoria Falls, Zimbabwe, May.
Phamoise, L.L. (1986). The status of informatics technology in Lesotho - Past, present and future. Proceeding of the Southern African Workshop on Informatics for Development, Victoria Falls, Zimbabwe, Ma 1986.
Pillai, A.S., Lal, V.N & Rao, K.S. (1997). Concurrent engineering experiences in high-tech defence projects. 1lr/. J- technology Management, 14(61718), pp.7 12-726.
Piore, M and Sabel, C., 1986, The New Industrial Divide, Basic Books.
Piragibe, C. (1985). Industria de informatica: Desenvolviment Brasileiro e mundial. Rio de Janeiro: Editor Campus.
Porteous, M. (1992). Revolution in a recession? Advanced technologies and Brazil's machine tool sector in the crisis. In H. Schmitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons from the Brazilian electronics and automation. Routledge, London and New York.
Porter, M (1990). The competitive advantage of nations. New York: The Free Press.
Postman, N. (1993). Technology: The surrender of culture to technology. Free Press, New York.
Preissl, B. (1990). Theses on the conditions of future world markets for information technology products. In F Meyer-Krahmer, J. Muller, & B. Preissl, eds. Information technology: Impacts, policies and future perspectives. Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp 181-93.
Proclamation No. 10211998, the Communications Proclamation, Gazette of Eritrean lows, vol. 8, No. 2, Asmara March 2, 1998.

Proclamation No. 53/1994, A Proclamation to Provide for the establishment of an Eritrean Information System Agency, Government of the State of Eritrea, Asmara, March 2, 1994.

Proclamation No. 59/l 994, Investment Proclamation, Government of the State of Eritrea, August 1994.

Proclamation No. 93/1997, Bank of Eritrea Proclamation, Gazette of Eritrean Laws, vol. 7, No. 2, Asmara March 10, 1997.

Proclamation No. 94/1997, Financial Institutions Proclamation, Gazette of Eritrean lows, vol. 7, No. 2, Asmara March 10, 1997.

Programme Formulation Mission for Sustainable Energy in Eritrea.

Rada, J. (1979). Microelectronics, information technology and its effects on developing countries. Paper prepared for the conference of socio-economic problems and potentialities of the application o microelectronics at work, Netherlands, Sept.

Rada, J F. (198?). Information technology and services. In O. Giarini ed. The emerging service economy. For the Services World Forum, Oxford: Pergamon Press, 1987,pp. 127-71.

Rahim, S. A. & Pennings, A. J (1987). Computerisation and development in Southeast Asia (Singapore: Asia Mass communications Research and Information Centre, 1987).

Ranis, G. & Fei, J. (1988). Development economics: What next. In G. Ranis & I' P. Schultz eds. The State of development economics. Oxford: Blackwell.

Ranis, G. (1990). Asian and Latin American experience: Lessons for Africa. Journal of International Development, 2 (2), pp. 15 -171.

Ranis, G. ed. (1992). Taiwan: from developing to mature economy. Westview Press, Boulder-San Francesco Oxford.

Rasmussen, J. (1990). Small urban centres and the development of local enterprises in Zimbabwe. In J. Baker ed. Small town Africa. Seminar Proceedings No. 23, Uppsala: Scandinavian Institute for African Studies.

Rasmussen, J. (1991). Small enterprises and their environment in Zimbabwe: Lessons from the flexible specialisation paradigm. Paper presented at EADI workshop on flexible specialisation an industrialisation in the Third World, June l4-16, 1991.

Rasmussen, J. (1992). The local entrepreneurial milieu: Enterprise networks in small Zimbabwean towns Doctoral thesis, Dept. of Geography, Roskilde University, Roskilde.

Rastogi, (1992). Electronics Production and export profile: 1991. Electronics: Information and Planning, 19 (9) June, India.

Rawski, T. G. (f980). China's transition to industrialisation: Producer goods and economic developments in the twentieth century. Ann Arbor: University of Michigan Press.

Reddy, P. & Sigurdson, J. (1997). Strategic location of R&D and emerging patterns of globalisation: the case of Astra Research Centre India. Int. J. Technology Management, 14(21314), pp.344-361.

Regan, E.J. (1989). The strategic importance of telecommunications to banking. In M. Jussawalla, T. Okuma, & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura contributions in economics and economic history series No. 83, Westport, Conn. And London Greenwood Press under the auspices of the East west Centre and the Japan Institute of International Affairs, pp.118-23.

Reynolds, L.G. (1983). The spread of economic growth to the Third World: 1950-1980. The Journal o Economic Literature, September, pp. 941-80.

Riddell, R. (1992). Manufacturing sector development in Zimbabwe and C6te d'Ivoire. In S. Lall, F. Stewart S. M. Wangwe eds. Alternative development strategies for African development. London: McMillan.

Roach, S.S. (1988). White-collar productivity: A glimmer of hope? New York: Morgan Stanley.

Roach, S. S. (1987). America's technology dilemma: a profile of the information economy. Memorandum. New York: Morgan Stanley.
Roach, S. S. (1992). Technology imperatives. New York: Morgan Stanley.
Robey, D. & Rodriguez-Diaz, A. (1989). The organisational and cultural context of systems implementation Case experience from Latin America. Information & Management,17.
Roenrer, M. & Stern, J. J. (1981). Cases in economic development: Projects, policies and strategies. London Butterworth.
Rosenberg, N (1982) Inside the black box: Technology and economics. Cambridge University Press.
Rosenberg, N. & Frischtak, C. (1984). Technological innovation and long waves. Cambridge Journal of Economics, 8 (1).
Rosenberg, N. (1976). The direction of technological change, inducement mechanisms and focusing devices. In Perspectives on technology, Cambridge University Press.
Rosovsky, H. (1972), What are the 'lessons' of Japanese economic history? In A. J. Youngson ed,. Economic development in the long run New York: St. Martin's Press.
Rweyemamu, J. F. (1975). The formulation of industrial strategy for Tanzania. Dar es Salam (mimeo).
Sagasti, F. & Cook, C. (1987). La ciencia y la tecnologia en America latina durante el decenio de los ochenta *Comercio Exterior*, 37 (12).
Sagasti, F. (1980). Science and technology for development: A review of schools of thought on science technology, development and technical change. Ottawa: International Development Research Centre (STPI Module I).
Saghafi, M. M. & Davidson, D. S, (1990). The new age of global competition in the semiconductor industry Enter the dragon. Columbia Journal of World Business, XXIV (1), pp. 60-70.
Salomon, J.-J. (1990). The importance of technology management for economic development in Africa. Int. J technology Management, 5(5), pp. 523 -536.
Sanders, R., Warford, J. & Wellenius, B. (1983). Telecommunications and economic development. Washington, DC: The World Bank.
Saxenian, A. (1985). The genesis of Silicon Valley. In P. Hall & A. Markusen eds. Silicon Landscapes. London Allen and Unwin.
Schein, E.H. (1992). The role of the CEO in the management of change: The case of information technology. I T. A. Kochan, & M. Useem eds. Transforming organisations. N.Y.: Oxford University Press, pp.80-95.
Schmitz, H. & Hewitt, T. (1992). An assessment of market reserve for the Brazilian computer industry. In H. Schmitz & J. Cassiolato eds. Hi-tech for industrial development: Lessons front the Brazilian experience in electronics and automation. London and New York: Routledge, pp. 21-52.
Schmitz, H. (1982). Manufacturing in the backyard: Case study on accumulation and employment in small scale Brazilian industry. Frances Pinter, London.
Schmookler, J. (1966). Invention and economic growth. Harvard University Press.
Schmtz, H. & Casiolato, J. eds. (1992) Hi-Tech for industrial development: Lessons from the Brazilian experience in electronics and automation, London and N.Y.: Routledge,
Scott-Morton, M.S. (1992). The effects of information technology on management and organisations. In T.A Kochan, & M. Useem eds . Transforming organisations. N.Y.: Oxford University Press, pp. 261-78.
Schumacher, E. F. (1972). The work of the intermediate technology development group in Africa. International Labour review, 106 (16), July 1972, pp.75-92.
Schumacher, E. F. (1973). Small is beautiful: Economics as if people mattered. New York: Harper & Row.
Schumpeter, J. A. (1943). Capitalism, socialism and democracy. New York Harper & Row.
Schumpeter, J. A. (1966). Capitalism, socialism and democracy. London: Allen & Unwin

Schware, R. (1992). Software industry entry strategies for developing countries: A 'walking on two legs proposition. World Development, 20 (2), February, pp. 143 -64.
Scitovsky, T. (1954). Two concepts of external economies. Journal of Political Economy, April.
Scott, R. J. P. (1989). A review of computers and education in Kenya in 1987. Information Technology for Development, 4(3).
Segal, A. (1993). Appropriate technology: The African experience. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.J.Brill: Leiden, New York, Koln.
SEI, 1989, Panorama do Setor de Informatica, Series Estatisticas, Vol. 2, No. 1, 20-1.
Sercovich, F. (1984) Exports of technology by newly industrialising countries: Brazll. World Development 12(5/6), May-June, p. 578.
Seyoum, B. (1990). Technology licensing in eastern Africa: A critical exposition and analysis. Aldershot Avebury, p. 25 l .
Sharif, M. N. (1986b). Measurement of technology for national development. Technological Forecasting an Social Change 29, pp. 119-172.
Sharil M.N. (1986a).Technological considerations in national planning. Technological Forecasting and Social Change 30, pp. 361-382.
Shin, T. & Hoagye Kim (1994). Research foresight activities and technological development in Korea: Science and technology policies in national R&D programs. Technological Forecasting and Social Change 45, pp. 31-45.
Shin, T., Hong, S.-K & Grupp, H. (1999). Technology foresight activities in Korea and in countries closing the technological gap. Technological Forecasting and Social Change, 60, pp. 71-84.
Shitima, M.N (1987). Information technology in government: The Zambian experience. Paper presented at the Eastern and Southern African workshop on Information technology in government, Rusape Zimbabwe, April.
Silva, E. B. (1992). Automation and work organisation: Contrasts between Brazilian and British car factories. I H. Schmitz & J. Cassiolato eds. Ili-tech for industrial development: Lessons from the Brazilian electronics and automation. Routledge, London and New York.
Simons, D. (1995). Debt, democracy and development: Sub-Saharan Africa in the 1990s. In Simon et al. eds. S. Slaaughter, & G. Rhoades, 1996, 'The Emergence of a Competitiveness Research and Development Policy coalition and the Commercialisation of Academic Science and Technology', Science Technology & Human Values,21 (3), pp. 303-339.
Sisodia, R. S. (1992). Singapore invests in the nation corporation. Harvard Business Review, May-June.
Smith, S.L. & Anderson, J. (1992). Over the threshold? Public and private choices in new information technology home working. In N. Gilbert, R. Burrows, & A. Pollert eds. Fordism and flexibility Divisions and change. New York: St, Martin's Press, pp. 170-85.
Soete, L. (1981) Technological dependency: A critical view. In D. Seers ed. Dependency theory: A critical assessment London: Frances Pinter.
Soete, L. (1985). International diffusion of technology, industrial development and technological leapfrogging World Development, 13(3), pp. 409-22.
Soete, L. (1987). The newly emerging information technology sector. In C. Freeman & L. Soete eds. Technical change and full employment. Oxford and N.Y.: Blackwell , pp. 189-220.
Soete, L. (1990). Opportunities and limitations to technological leapfrogging. Technology, Trade Policy and the Uruguay Round UNCTAD, New York, p.9.
Soifer, R. (1984). Exports of technology by newly industrialising countries: Argentina. World Development 12 (5 /6), May - June, p.628.

Soon, T.T. & Huat, T.C. (1991). Role of transnational corporations in transfer of technology to Singapore. In M Chatterji ed. (1990)

Soumi, R. (1992). Information technology and corporate culture-The uneasy symbiosis. Liiketaloudellinen Aikukauskirja, 41 (1), pp.27 -41.

Spero, J.E. (1989). The information revolution and financial services: A new north-south issue? In M. Jussawalla, T. Okuma & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura, contributions in economics and economic history series No. 83, Westport, Conn. And London: Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp. 109-17.

Stein, H. (1995). Asia industrialisation and Africa: Studies in policy alternatives to structural adjustment. St Martin's Press, New York.

Stewart, F. & James, J. ed.(1982).Theeconomicsofnewtechnologyindevelopingcountries.London:France Pinter.

Stewart, F. & Ghani E. (1991). How significant are externalities for development? World Development, 19(6) November, pp .569-594.

Stewart, F. (1977) Technology and underdevelopment. London: Macmillan.

Stewalt, F. (1979) International technology transfer: Issues and policy options. Washington, DC: World Bank Staff Working Paper No. 344.

Stewart, F (1983). Technical change in the north: Some implications for southern options. In L. Passinetti ed. Proceedings of I. E.A. Congress, Madrid.

Stewart, F. and Ranis, G., 1990, "Macro-policies for appropriate Technology: a Synthesis of Findings', in Stewart, Thomas and de Wilde (1990).

Stewart, F., Lall S., & Wangwe S. eds. (1992). Alternative development strategies in Sub-Saharan. McMillan London.

Stewart, F., Thomas, H & de Wilde T. eds. (1990). The other policy: The influence of policies on technology choice and small enterprise development. IT Publications and Appropriate Technology International.

Stiglitz, J E. (1989). Markets and development. National bureau of Economic Research, Working paper 2961 May, Stanford University.

Strassmann, P. (1985). Information payoff. The transformation of work in the electronics age. New York: The Free Press.

Strassmann, P. A. (1990). The business value of computers. New Canaan, CT: Information Economics Press Strategy and Terms of Reference for Constructing a Geographic Information System and Database for the NFIS -Eritrea,1997.

Su, Shao-zhi (1989). Telecommunication and development: The case of China. In M. Jussawalla, T. Okuma & T. Araki eds. Information technology and global interdependence. Foreword by Kazuo Ogura contributions in economics and economic history series No. 83, Westport, Conn, & London Greenwood Press under the auspices of the East-west Centre and the Japan Institute of International Affairs, pp. 289-92.

Sutherland, E. (1991). The meaning of strategic information technology-- An analysis of the literature. In E. Sutherland & Y. Morieux eds. Easiness strategy and information technology. London and N.Y.: Routledge, pp.3-25.

Sverrisson, A. (1992). Gradual diffusion of flexible techniques in small and medium sized enterprises networks Paper Presented for EADI Industrialisation Strategies Working Group Workshop on NE Approaches to Industrialisation: Flexible Production and Innovation Networks in the South, Research Policy Institute: Lund.

Sweeny, G. (1996). Learning efficiency, technological change and economic progress. Int. J. of Technology Management, Special Issue on Information Flow, 11 (1/2), pp.5-27.
Symons, V. & C. Walsham (1990). The evolution of information systems: A critique. Journal of Applied Systems Analysis,15.
Tang, H K & Yeo, K.T. (1995). Technology, entrepreneurship and national development: Lessons from Singapore. Int. J. Technology Management, 10 (7i8), pp. 797-814.
Tapscott, D, & Caston, A. (1993) Paradigm shift: The new promise of information technology. McGrow-Hill Inc., New York.
Taylor, D. & Obudhu, R. (1977). The Computer and Africa. New York: Praeger.
Taylor, D., and R, Obudhu, 1977, The Computer and Africa, New York: Praeger.
Technology Exhibition '98, October 15-17, Asmara, Eritrea.
Teitel, S. (1981). Towards an understanding of technical change in semi-industrial countries. Research Policy 10 (2).
Teitel, S. (1984). Technology creation in semi-industrial economies. Journal of Development Economics, 16 (1) pp 39-61.
Tesfai Haile (1996). Economic development through industrial co-operation in the Horn of Africa: The Eritrea experience. Trading Places series, Life and Peace Institute, Uppsala, June, pp.55.
Teubal, M. (1996). R&D and technology policy in NICs as learning processes. World Development, 24(3) pp.449-460.
The First African Regional Conference on Science and Technology, 1V95, ECA/NRD/S&T/ARCST/1 November 1995, UN, http://www.cygnus.sas.upcnn.ed!/aftica-studiesiECA./cca-stconfr.htm
The world of learning 1995, 4th ed., Europa Publications Limited, London 1995.
Thulstrup, E. W. (1995). The role of basic science training in the development process. Paper for the International Conference on Donor Support to Development Oriented Research in Basic Science Organised by SAREC and Uppsala University, June 1995.
Thulstrup, E.W. ed. (1996). Research training for development. Proceedings of a conference on research training for countries with limited research capacity. Roskilde University Press.
Tiffin, S. & Osotimehin, F. (1993). Innovation of new and emerging technology for industrial development in Africa. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.J.Brill Leiden. New York, Koln.
Tiffin, S., Adjebeng-Asem, S. & Afolabi, O. (1987). Technological innovation and technical entrepreneurship for the development of Nigerian agricultural machinery industry. World Development, 15 (3), pp.387-398.
Tigre, P. B. (1983). Technology and competition in the Brazilian computer industry. London: Frances Pinter.
Toffler, Alvin, 1980, The Third Wave, New York: Bentam.
Tsao Yuan, Lee ed. (1991). Growth triangle: The Johor-Singapore-Riau experience. Institute of Southeast Asian Studies and Institute of Policy Studies, Singapore.
UNECA (1989a). African Alternative Framework to Structural Adjustment Programmes for Socio-economic recovery and Transformation, E/ECA/CM. I5l6/Rev. 3 , Addis Ababa.
UNECA (1989b). African Alternative Framework to Structural Adjustment Programmes for Socio-economic Recovery and Transformation, ECA, Addis Ababa.
UNECA (1991). ECA/IHSD/INS/004/91, September, output 1.2 (ii).
UNECA (1991). Technical Publication on Ways and Means of Developing Appropriate Industrial Technology and Human Resources through Co-operative Arrangements between Universities, industrial Research and Development Institutions and Enterprises in African Countries, ECA/IHSD,{NS/OO4|9| September 1991, output 1.2 (ii).
UNESCO (1979). An introduction to policy analysis in science and technology. No. 46, Paris.

UNESCO (1986). Comparative study on the national science and technology policy-making bodies in the countries of West Africa. Science policy studies and documents, no.58, Pads: UNESCO, p. 103.
UNESCO (1987). Comparative studies on the national science and technology policy-making bodies in the countries of Eastern and Southern Africa. Science policy studies and documents, no. 66, Paris UNESCO, p.186.
UNESCO (1988). Science technology and endogenous development in Africa: Castafrica II. Report of the conference and analysis of trends, problems and prospects. Science Policy Studies and Documents, no. 69, United Nations Educational, Scientific and Cultural Organisation. - Paris: UNESCO, p. 250.
UNESCO (1993). World Science Report.
UNIDO (1981). Technological self-reliance of the developing countries towards operational strategies. No. 15 1981, pp. 3-46.
UNIDO (1985) Survey of government policies in informatics. UNIDO/IS.526, 4 April.
UNIDO (1989). Computers for industrial management in Africa: The case of Nigeria. (PPD.126, 10 July 1989).
UNIDO (1990). Computers for industrial management in Africa: The case of C6te d'Ivoire, (PPD.154, 21 Marc 1990).
UNIDO (1990). Computers for industrial management in Africa: The case of Ethiopia. (PPD.176, 18 September 1990).
UNIDO (1991). Computers for industrial management in Africa: The case of Algeria. (PPD.18I, 7 January 1991).
UNITED NATIONS (I97I). The application of computer technology for development.
UNITED NATIONS (Industrial Development Organisation) (1981). Technological self-reliance of the developing countries towards operational strategies. No. 15, pp. 3-46.
University of Asmara Statistical Data, 1997.
Utterback, J.M.& Abernathy, W.J.(1975).A dynamic model of process and product innovation. Omega, 3, pp 639-656.
Valaskakis, K. (1982). Leapfrog strategy in the information age. In H. F. Didsburg, Jr. ed. Communications and the future. World Future Society, Bethesda, MD.
Van der Meulen, B.J.R. (1998). Science policies as principal-agent games: Institutionalisation and pat dependency in the relation between government and science. Research Policy, 217, pp.397-414.
Van Engelen, J. (1991). The role of information systems in marketing success. In E. Sutherland & Y. Morieu eds. Business strategy and information technology. London and N.Y.: Routledge, pp.72-84.
Vickely, C. (1990). Production oriented information technology policy in Japan and Europe. In F. Meyer-Krahmer, J. Muller, & B. Preissl eds. Information technology: Impacts, policies and future perspectives Promotion of mutual understanding between Europe and Japan, Berlin: Springer, pp. 60-87.
Vitta, P. B (1990). Technology policy in Sub-Saharan Africa: Why the dream remains unfulfilled. World Development, 8 (11), pp.1471-1480.
Vitta, -Paul B. (1993). Management of technology policy in Sub-Saharan Africa: The policy researchers burden. In A. Ahmed ed. Science and technology policy for economic development in Africa. E.J.Brill Leiden, New York, Koln.
Wadia, B. H. (1989). The electronic industry in the African countries: Zambia. IDrNG.491I5 (SPEC.), 2 October.
Walsh, V. (1988). Technology and the competitiveness of small countries: Review. In C. Freeman & B. A Lundvall eds. Small countries facing technological revolution London and New York: Pinter distributed by Columbia University Press, pp 37-66.
Walton, R.E. (1990). Up and running, integration information technology and the organisation. Harvard Business School Press, Boston.

Wandiga, S. O. (1996). Research training: The Kenyan experience. Proceedings of a conference on research training for countries with limited research capacity. Roskilde University Press.
Wangwe, S. (1988). Technology transformation in the Third World: The case of Tanzania. Paper presented t WIDER Conference on Development and Technological Transformation in the Third World. Helsinki August 1988.
Wangwe, S (1992). Building indigenous technological capacity: A case study of selected industries in Tanzania. In Stewart et al. eds. 1992.
Wangwe, S.M. ed. (1995) Exporting Africa: Technology, trade, and industrialisation in Sub-Saharan Africa LINU/INTECH studies in new technologies and development, London: Routledge, p.436.
War-Torn Societies Project - Eritrea (Infrastructure), Final National Workshop, Asmara 5-6 December 1996.
Weaver, J. & Jameson, K. (1981). Economic development: Competing paradigms. University Press of America, Washington, DC.
Wei, C.-C. (1997). The current status of R&D activities in Taiwan. Int. J. Technology Managem.ent, 13(5/6), pp 563-570.
Wesphal, L.E. & Kim, K. S. (1977). Industrial policy and development in Korea. Washington, DC. World Bank Staff Working Paper No.263.
Westphal, L. E. (1990). Industrial policy in an export-propelled economy: Lessons form South Korea' experiences. Journal of Economic Perspectives,4(3), pp. 41-59.
Westphal, L.E (1981). Empirical justification for infant industry protection. Washington, DC: World Bank, Staff Paper No. 445.
Westphal, L. E., Rhee, Y.W. & Pursell, C. (1979). Foreign influences on Korea's industrial development. Oxford Bulletin of Economics and Statistics, 41 (4), pp. 359-388.
Westphal, L. E, Rhee, Y.W. & Pursell, G. (1981). Korean industrial conference: Where it came from Washington, DC: World Bank, Staff Working Paper No. 469.
Westphal, L. E., Rhee, Y.W. & Pursell, G. (1984). Sources of technological capability in South Korea. In Fransman and King (1984).
Westphal, L.E., Rhee, Y.W., Kim, L. & Amsden, A. H. (1984). Republic of Korea. World Development, Special Issue on Exports of Technology by Newly-Industrialising Countries , Vol. 12, Nos. 5/6, pp. 505-33.
Whitaker, J. S. (1986). The policy setting: Crisis and consensus. In R. J. Berg & J. S. Whitaker eds. Strategies for Africa development University of California Press, Berkely-Los Angeles-London.
White, E & Campos, J. (1986). Alternative technology sources for developing countries: The role of small an medium-sized enterprises from industrialised countries. CEDREI, Buenos Aires.
Widstland, C (1992). Tanzania: Development of scientific research and SAREC support 1977-1991. SARE Documentation.
Woherem, E E. (1993). Information technology in Africa: Challenges and opportunities. African Centre for Technology Studies technology policy series no. 5, Nairobi, Kenya: ACTS Press, African Centre for Technology Studies and Research Institute for Knowledge Systems, 1993.
Wong Ko Wang, N. (1987). Information technology in government: Mauritius. Paper presented at the Easter and Southern African workshop on information technology in government. Rusape, Zimbabwe, April.
Wong, J.K, (1995). Technology transfer in Thailand: descriptive validation of a technology transfer model. 1n J. Technology Management, 1 0 (7/8), pp. 788-796.
Working Protocol between Strategic Planning & International Economic Co-operation Department, Ministry o Finance and Development, Ministry of foreign affairs, and the Bank of Eritrea, January 1994.
World Bank (1981). Accelerated development in Sub-Saharan Africa. Berg Report, Washington, DC.
World Bank (1987). Kenya: Industrial Sector Policies for Investment and Export, Washing-ton DC: World Bank.
World Bank (1989). Sub-Saharan Africa: Front Crisis to Sustainable Growth, Washington, DC.

World Bank (1989). Sub-Saharan Africa: From crisis to sustainable growth. The World Bank, Washington D.C.
World Bank (1991). The information technology revolution and economic development.
World Bank (1992). World Development report 1992.
World Bank (1993). The East Asian Miracle: Economic Growth and Public Policy, Published for the World Bank, oxford University Press.
World Bank (1995). Increasing Internet connectivity in Sub-Saharan Africa issues, options, and World Bank Group role. http://www. worldbank.org/Aftdr/connect/incrint.htm
World Bank (1999). World Development Report: Knowledge for development, 1998-99.
Woronoff, I. (1992). Asia's "Miracle" Economies. 2nd ed. M. E. Sharpe, Inc. Armonk, New York, London England.
Xue, L. (1997). Promoting industrial R&D and high-tech development through Science Parks: the Taiwan experience and its implications for developing countries', Int. J. Technology Management, Special Issue on R&D Management, vol. 13, No. 718, pp.744-761.
Yacob Fisseha (1996). Micro, small and medium enterprises in Eritrea. Eritrean Studies Review, 1 (2), Fall.
Yang, C., Tarng, M-Y. & Hsu, F-M. (1997). The management of science and technology projects in Taiwan. Int. J. Technology Management, 14 (5), pp. 528-538.
Yap, C S. (1989). Computerisation problems facing small and medium enterprises: The experience of Singapore. Proceedings of the Twentieth Annual Meeting of the Midwest Decision Sciences Institute, pp, 128-134, Miami University, Ohio.
Yates, J. (1992). Information technology and business processes in the 20th century insurance industry. In W. J. Housman ed. Business and economic history. Papers presented at the 38th annual meeting of the Business History Conference, March 6-7, 1992, Pasadena, California, Second Series, Vol. 21 Williamsburg, Va.: Business History Conference, Department of Economics, College of William an Mary,pp.3l7-25.
Yemane Mesghena (1988). Italian colonialism' A case study of Eritrea. 1869-1934, Lund.
Yin, R.K. (1994), Case study research: Design and method. 2nd ed., SAGE Publications, Thousand Oaks California.
Yonazi, E. (1986) The status of computer applications in Tanzania. Proceedings of a Regional Workshop o Fundamentals of Microprocessor-based Systems, Nairobi, Kenya, 1986.
Young, C. (1986). Africa's colonial legacy. In R. J. Berg & J. S. Whitaker eds. Strategies for Africa development, University of California Press, Berkeley - Los Angeles - London.
Young, D.N. (1986). The impact of technology on the insurance industry. G. Faulhaber, E. Noam, & R. Tasle ed. Services in transition: The impact of information technology on the service sector, Cambridge Mass.: Harper & Row, Ballinger, pp.31-43.
Zwangobani, E. (1985). Government policy on the acquisition of data processing technology.
Zwangobani, E. (1988). National informatics policies in Sub-Saharan Africa. Paper presented in National Information and Informatics Policies in Africa: Report and Proceedings of a Regional Seminar, Addis Ababa, Ethiopia,28 Nov.- 1 Dec., 1988.
Zymelman, M. (1990). Science, education, and development in Sub-Saharan Africa. World Bank technical Paper No. 124, Africa Technical Department Series.